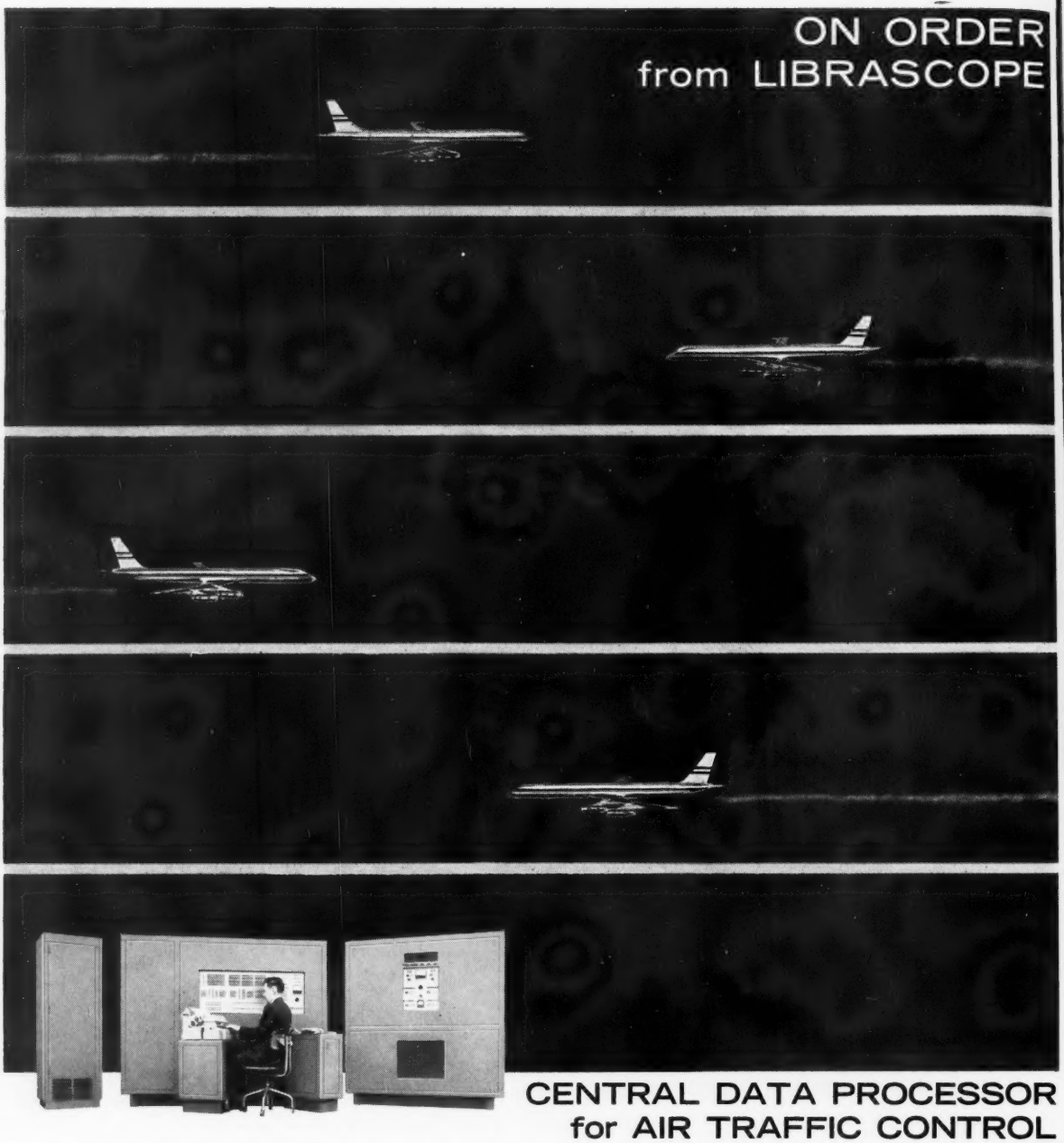
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JULY 1961

ENTRANCE—
U. S. LUNAR PROGRAM

Nuclear Rockets and the Space Challenge . . . . . H. Finger
Communication Satellites—How High? . . . . . G. Mueller, et al.
The Solar Spectrum in Space . . . . . R. Tousey



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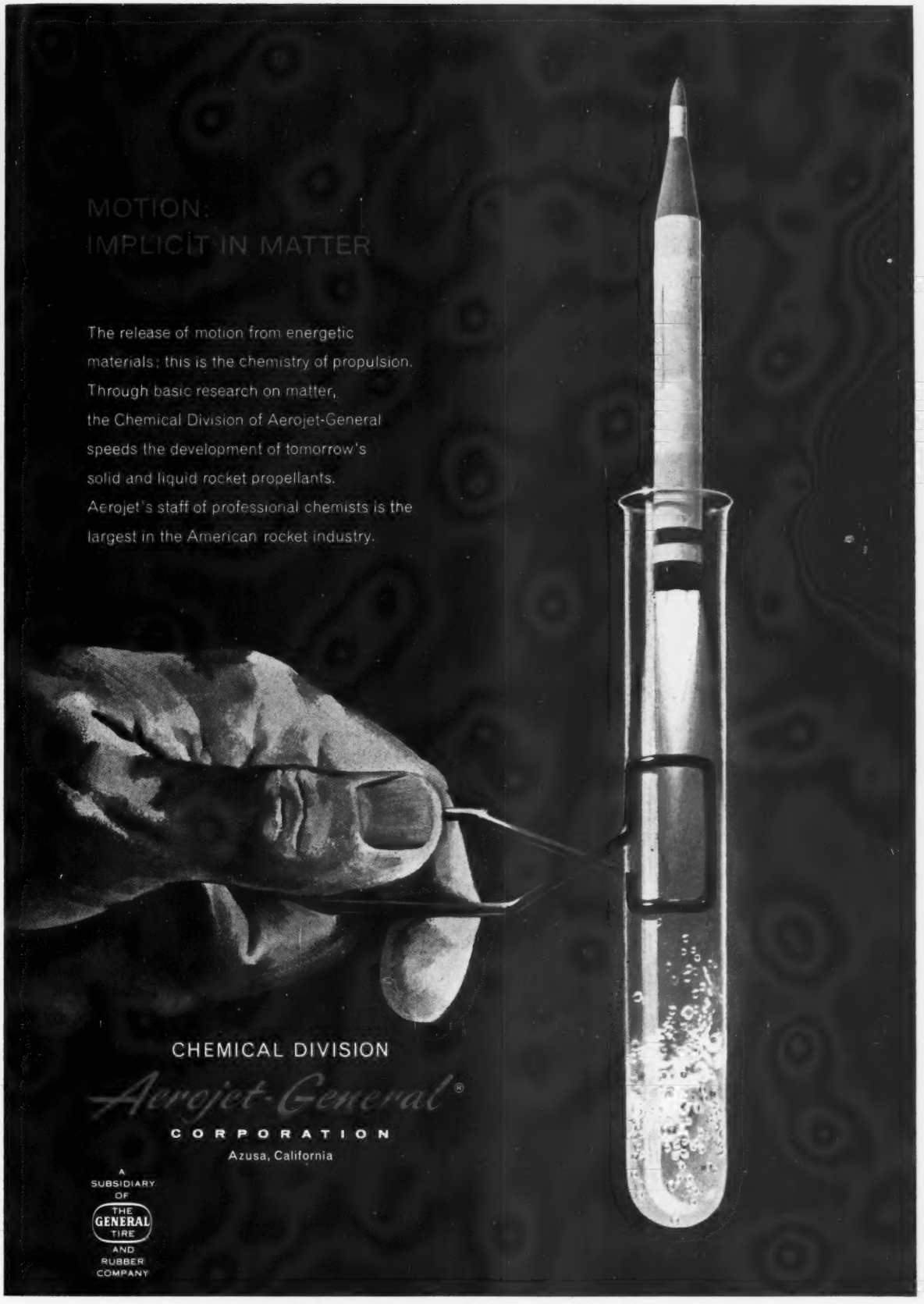
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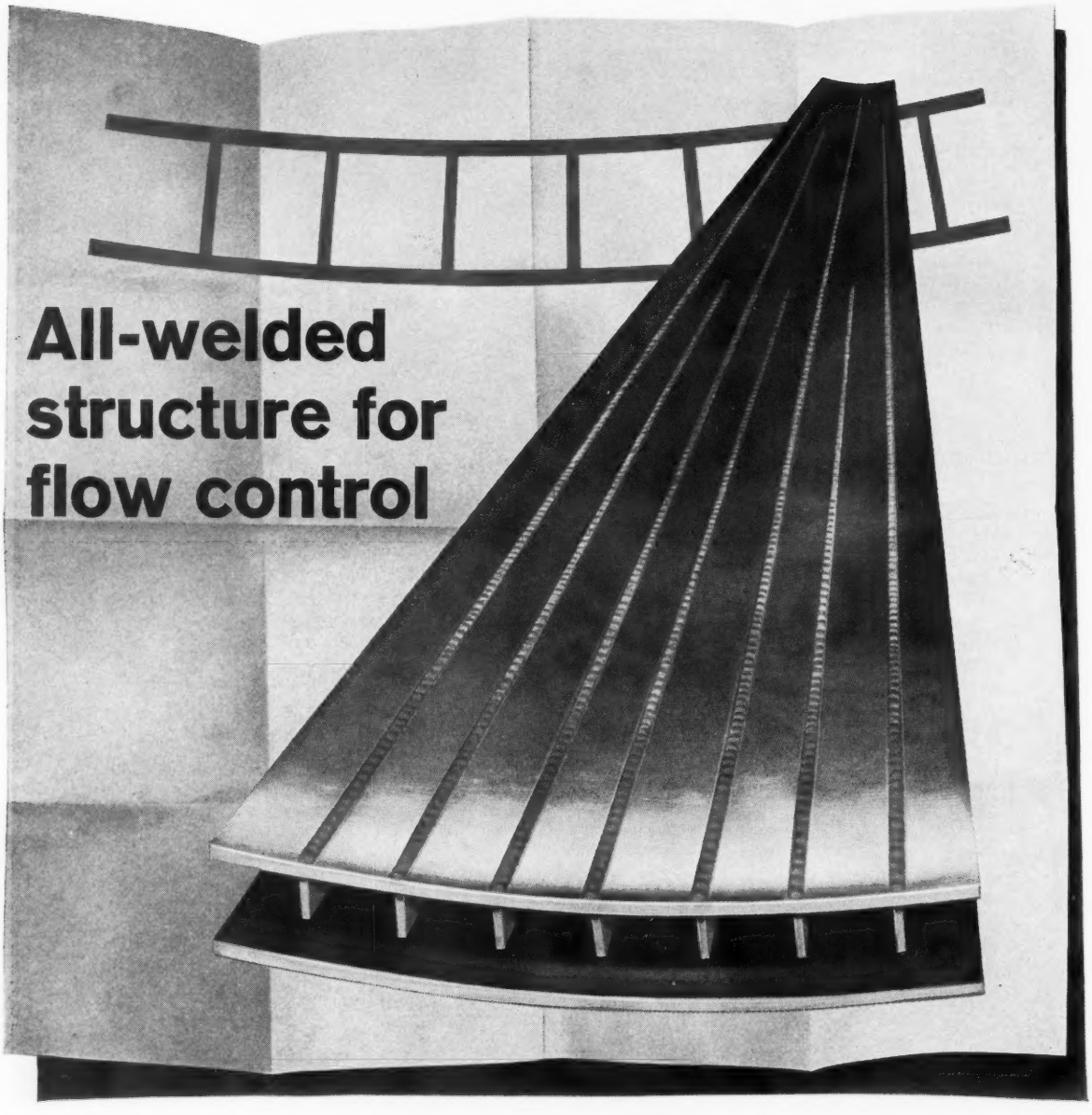

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PRODUCT Budd DEVELOPMENT

COVER: Design of controls for lifting re-entry configurations will require careful attention to insure adequate effectiveness over speed, altitude, and attitude range of flight. This NASA Ames Research Center photo shows hypervelocity flow about a lifting body with controls extended and thereby immersed in a very hot and radiating gas cap. (ASTRO cover plaques 11 X 12 in. are available from ARS Headquarters at $2.00 each.)

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A PUBLICATION OF THE AMERICAN ROCKET SOCIETY INC.

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Astro notes

MAN IN SPACE

• The Astronaut flying MR-4 this month will have fewer things to do than did Alan Shepard and more time for visual observations. The MR-4 capsule will be equipped with the new trapazoidal "picture" window, which has twice the area as the one in Shepard's capsule.

• The MR-4 Astronaut will also perform all the control tasks assigned to Shepard, and will use for the first time the "rate-command" manual attitude-control system. The command-rate system is more precise than the manual-proportional, or "bang-bang," equipment of Shepard's capsule. Rate command permits the Astronaut to control electrically the opening of reaction-jet valves and thus pinpoint the amount of thrust he needs.

• Astronaut Shepard's performance in the first Project Mercury ballistic shot gave space-vehicle designers new grounds for assigning control functions to a human operator rather than a machine. Speaking before an ARS luncheon in New York in June, Wernher von Braun mentioned that Apollo crews will be assigned much greater command function than might have been expected. The Martin Co. study group on Project Apollo, for instance, found manual control of spacecraft exact and flexible in many maneuvers including rendezvous.

• Some Apollo spacecraft will include the propulsive power and docking equipment for orbital rendezvous. The engines for both orbital rendezvous and re-entry maneuvers look as if they take controllable-thrust storables, probably mixed hydrazines and nitrogen tetroxide.

• Robert Voas and other Project Mercury training psychologists were highly pleased with Astronaut Shepard's accuracy in the manual-control maneuvers, and particularly the crucial retrorocket firing exercise. "His performance of these activities was not only within the limits required for a successful mission, but the quality of the performance was comparable to that achieved on the procedures trainer under optimal environmental conditions," Dr. Voas wrote. "The close correspondence between attitude maneuvers on manual control in the simulator and those in flight indicate that the trainers used in the Mercury program were relatively successful in reproducing the vehicle characteristics in flight."

• Shepard himself had some definite ideas on future astronaut training. For one thing, he said, the two-year program he and his comrades pursued can undoubtedly be shortened. In this connection, he laid particular stress on the usefulness of the Johnsville centrifuge, the Mercury procedures trainers at NASA-Langley, and Cape Canaveral, and the thorough preflight workouts with Mercury capsules at the Cape before they are fitted to the rocket. Shepard's other point had to do with medical examinations: "I hope that fewer body-fluid samples will be required in the future. I felt as though an unusual number of needles were used."

• An interesting parallel has appeared in the pulse rates of Cosmonaut Yuri Gagarin and Astronaut Shepard. According to Soviet statements, Gagarin's pulse reached 109 at three minutes before takeoff

President Kennedy's Statement on New Space Missions
Excerpts from Speech before Congress on May 25, 1961

The dynamic achievements in space which occurred in recent weeks should have made clear to us all, as did the Sputnik in 1957, the impact of this adventure on the minds of men everywhere. . .

Now it is time to take longer strides—time for a great new American enterprise—time for this nation to take a clearly leading role in space achievement which, in many ways, may hold the key to our future on earth.

I believe we possess all the resources and talents necessary. But the facts of the matter are that we have never made the national decisions or marshaled the national resources for such leadership.

I therefore ask the Congress, above and beyond the increase I have earlier requested for space activity, to provide the funds which are needed to meet the following national goals:

First, I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth. No single space project in this period will be more impressive to mankind or more important for the long-range exploration of space. And none will be so difficult or expensive to accomplish.

We propose to accelerate the development of the appropriate lunar spacecraft.

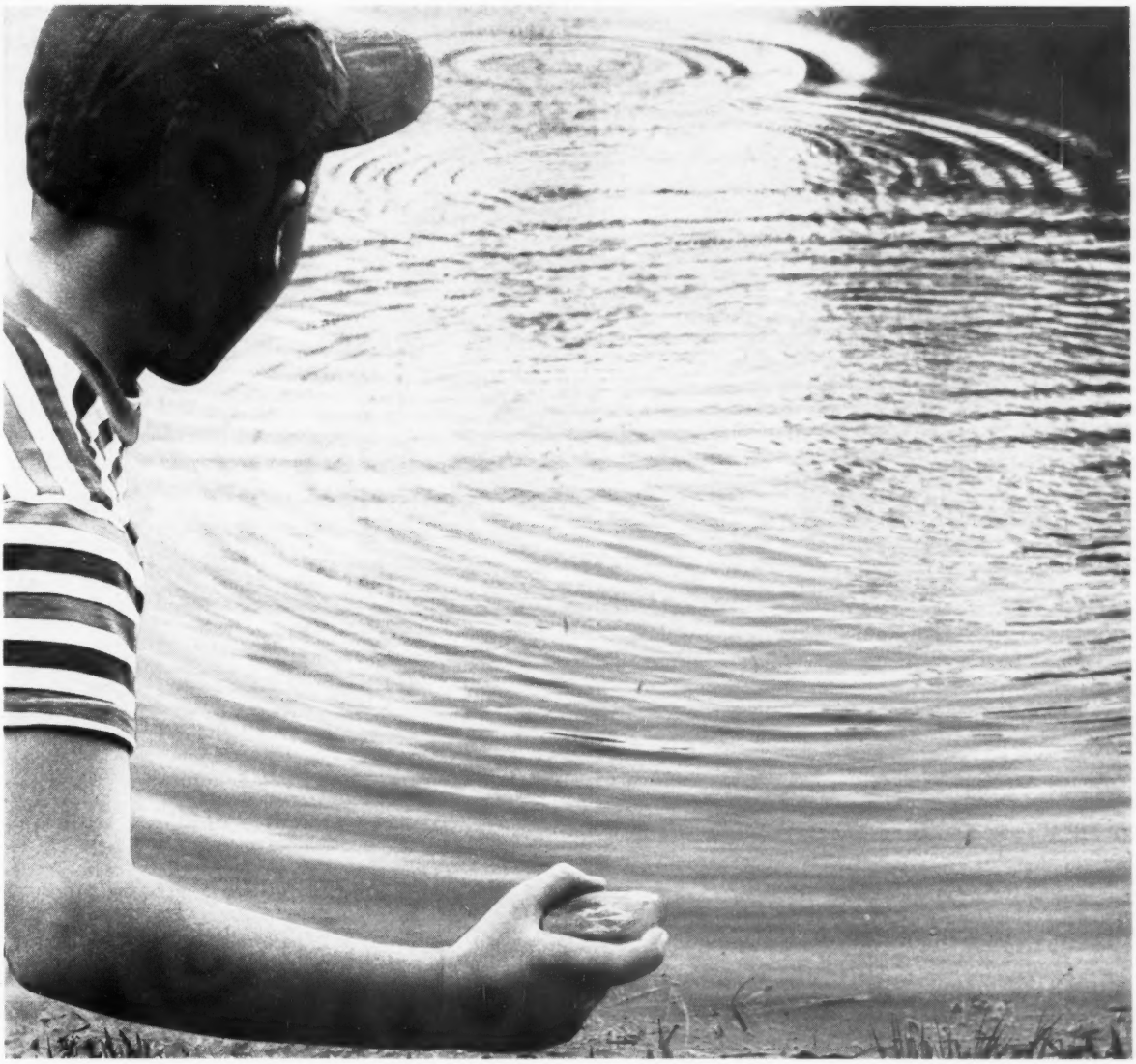
We propose to develop alternate liquid- and solid-fuel boosters much larger than any now being developed, until certain which is superior.

We propose additional funds for other engine development and for unmanned explorations—explorations which are particularly important for one purpose which this nation will never overlook; the survival of the man who first makes this daring flight. But in a very real sense, it will not be one man going to the moon. We make this judgment affirmatively: It will be an entire nation. For all of us must work to put him there.

Let it be clear that this is a judgment which the members of the Congress must finally make. Let it be clear that I am asking the Congress and the country to accept a firm commitment to a new course of action—a cost which will last for many years and carry very heavy costs—$531 million in fiscal '62, and an estimated $7 billion to $9 billion additional over the next five years. . .

The lead article in this month's *Astronautics* discusses ramifications of this new prospectus for the U.S. space program. A table on page 104 summarizes funding details. It is interesting that House hearings on the 1962 NASA authorization held in March and April this year run to more than a thousand pages.

What can a skipping stone teach us about re-entry from space?



One promising approach to the problem of atmosphere re-entry is called the skip-glide path. The spaceship would follow an undulating trajectory, glancing off the atmosphere to lose its speed, much as a stone skips across the water. The necessary lift might be provided by a deployable pneumatic wing which would inflate on entering the atmosphere.

This and other approaches to aerospace deceleration are now being studied and evaluated at Northrop's Radioplane Division as part of its comprehensive program in landing and recovery systems. Long recognized as the leader in all aspects of paradynamics, Radioplane is fast becoming the industry's standard for space and aerospace landing systems. Active programs now include lunar soft landing studies, aerospace decelerators, and re-entry drag devices as well as recovery and landing systems for *all manned space vehicles actively scheduled by the U.S.*

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"due to slight emotional tension," reaching a maximum of 158 beats per minute during the acceleration period. Shepard's pulse averaged 80 during the countdown routine, reached 108 shortly before liftoff, 126 at liftoff, and a maximum of 138 at engine cutoff and booster separation. During the ensuing 304 sec of weightlessness (except for 23 sec of retro-fire), his pulse gradually dropped back to 108, rising to 132 shortly after peak re-entry G, then dropping to about 110 at the time telemetry was lost.

• The Russians offered the Federation Aeronautique Internationale documentation of Gagarin's flight to support their claims for orbital altitude, payload, and duration records. Gagarin was launched at the Cosmodrome at Baikonur to the east of the Sea of Aral (a launching site long familiar to western intelligence), and he returned to earth 18 mi southwest of Engel's (a point dictated by celestial mechanics, since the Vostok had no lift capability). But Western observers were most disappointed where they had most hoped for information—a description of the Soviet booster. The Russians said merely that their booster "had six engines at the moment of launching, with a total boost of 20-million hp.

• Translating horsepower, U.S. engineers came up with a figure of 1,250,000-lb thrust for the Soviet booster, about 50% more than the 800,000 lb really necessary. Closer inspection of the Soviet statement showed that the Russians weren't saying that all six engines were firing during the launching, nor that the 20-million hp was produced at any single instant. From the wording and other facts available, it appeared the Russians were adding first-and second-stage thrust to arrive at a true but quite meaningless figure of their booster's power. It remained to be seen whether FAI would accept the Soviet description as adequate documentation for purposes of granting official recognition of the Vostok records.

• With NASA test pilot Joe Walker at the controls, the X-15 rocket-powered research aircraft set another new speed record: 3307 mph, or Mach 4.9. Target of the flight was Mach 5.1, and the original speed figure was given as 3370 mph. This was revised downward as a result of further data processing.

BOOSTERS—BIGGER, BETTER

• NASA's Marshall Space Flight Center has re-sized the C-1 Saturn test flight vehicle to a two-stage rocket, dropping the Convair Centaur stage (S-V). Present target of the 10-shot test program is a 150-ft two-stage C-1 equipped with large aerodynamic fins on the first stage (see page 21). The performance guarantee of 20,000-lb payload in a 300-mi. orbit will be maintained by elongating first-stage (S-1) tankage 6 ft to accommodate an additional 100,000 lb of propellant, along with the previously announced expansion of the S-IV lox-liquid hydrogen second stage from 70,000-to 90,000-lb thrust. Last four C-1 prototype flight vehicles will carry "boilerplate" and possibly production versions of the Apollo-A manned orbiting laboratory.

• The implication of Marshall SFC changes seems to be a decision to eliminate the Convair S-V stage on manned flights. This stage "will not be used until later in the C-1 program and for some flights of the advanced Saturn C-2 configuration." It remains to be seen whether a three-stage C-2 Saturn can carry out the circumlunar mission planned for Apollo-B. Incidentally, officials of NASA's Space Task Group at Langley AFB, Va., are disgruntled with Huntsville's quick changes in the Saturn. They want to crystallize the booster as soon as possible for Apollo planning purposes.

• Although most of the extra money President Kennedy wants Congress to give the Defense Dept. to support his all-out drive for the moon is earmarked for development of a solid-propellant version of the Nova super-booster, an item of $15 million was requested to develop a Centaur backup vehicle based on the storable-propellant Titan II booster. This booster plus an Agena-B third stage is supposed to have greater lift capacity than Atlas-Centaur. Lift is becoming critical in the case of the Army's Advent 24-hr equatorial communication satellite, but there are signs the Pentagon and NASA are not at all reluctant to commence work on an alternative to Centaur at this time.

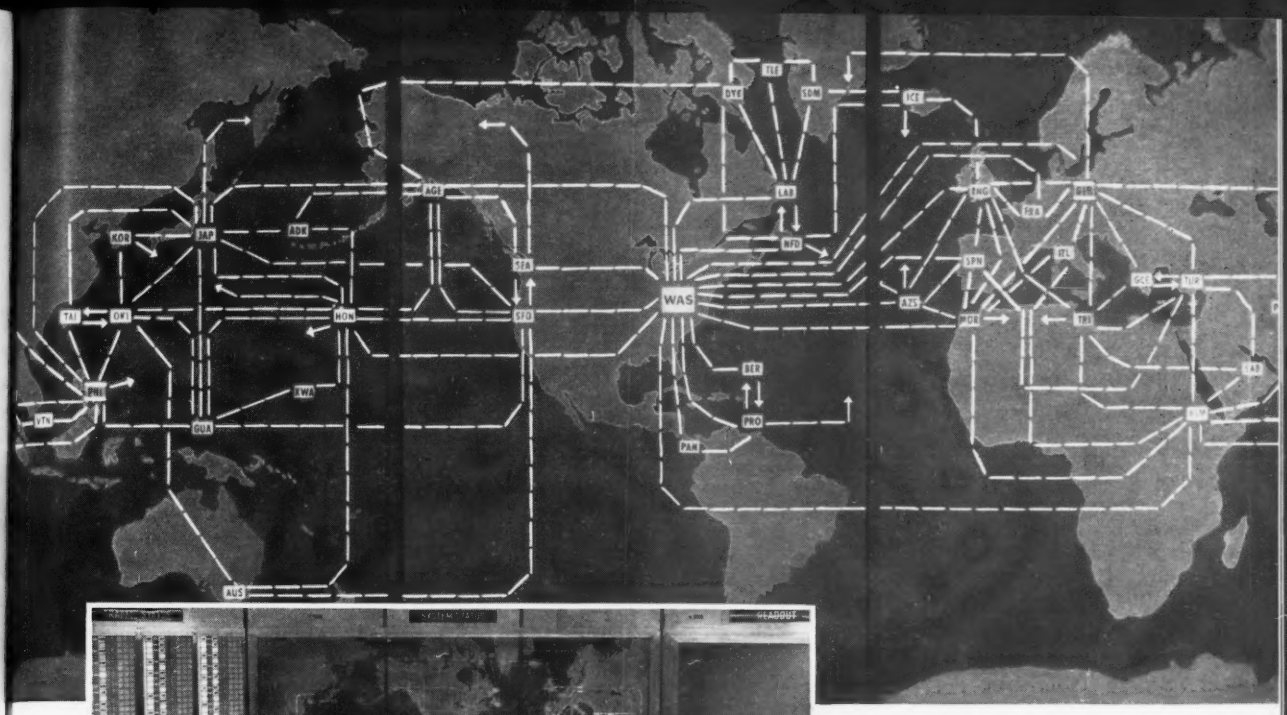
• Titan II, according to a fact sheet just made available by the Air Force, measures 102 ft in height, 10 ft in diam (both stages), and 150 tons in gross weight with propellant aboard. It produces 430,000-lb thrust in the first stage and 100,000 lb in the second stage. Titan I, in comparison, measures 98 ft high (10 ft diam for first stage and 8 ft for second), weighs 110 tons gross, and gives 300,000-lb thrust for first stage and 80,000 for the second. Part of the increased performance is necessary to offset the reduced specific impulse of the storables (nitrogen tetroxide and mixed hydrazines) but there is a margin left over to provide for increased warhead weight. Titan II can haul twice the megatonnage of Atlas and eight times that of Minuteman.

• Murphy's Law ("Whatever can go wrong will go wrong") dealt the Saturn program a nasty slap last month after an ominous accumulation of success. The SA-1 (initial flight) test vehicle worked perfectly for 111 sec during its final static firing at NASA's Marshall SFC, and was torn down for an extended checkout. Work was completed on the 310-ft mobile Saturn launch tower at Cape Canaveral, and it was turned over to the government. Then the special barge, *Palaemon*, arrived at Huntsville to pick up the test booster.

• But before the Palaemon could return to the Cape, disaster struck: A lock broke on Wheeler Dam some 40 mi. down the Tennessee River from Huntsville and it looked like months before it could be repaired. Meantime, it appeared the booster would have to be disassembled and shipped piecemeal to Cape Canaveral, a development Marshall had wanted to avoid.

• NASA Marshall was expected to announce shortly the selection of two or more companies to undertake Phase II negotiations for development of the S-II lox-liquid hydrogen stage for the C-2 Saturn. It said seven companies had submitted proposals in the first phase of the selection process: Aerojet-General, Chrysler Corp., Douglas Aircraft, Lockhead Aircraft, Martin Co., Convair, and North American Aviation, Inc. The S-II, measuring 74 ft in length, 21.5 ft in diam and 800,000 ft in thrust, will be the largest rocket project undertaken by U.S. industry.

• The Air Force gave Douglas Aircraft an order for 22 additional Thor DM-21 rockets to serve as space boosters for the Discoverer, Transit, Nimbus, and other programs. The DM-21 has a shorter, lighter airframe than earlier models and features a 165,000-lb-thrust engine—one 10% more powerful than the initial powerplant. The contract will



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extend Douglas Thor production to July 1962.

• Marshall SFC awarded the Martin Co. a $75,000 contract to study the various methods of landing a lunar mission on the moon. Three basic missions are to be studied—lunar landing and immediate return to the earth for three men, lunar landing and a 30-day stay on the moon for 3 men (the Apollo-C crew would remain 3-4 days), and a permanent moon base to accommodate 10 to 12 men.

• Using a small experimental static-firing motor, Amcel Propulsion demonstrated the use of separate oxidizer and fuel grains in a single unit to achieve a variable thrust. A valve between the grain chambers controls combustion.

• Atlantic Research will deliver twelve of its 20-ft Iris sounding rockets to NASA-Goddard SFC under a $248,000 contract, the first for the solid bird.

• The Army will build a static-firing facility for large solid-propellant motors at Redstone Arsenal. Motors for Nike-Zeus will be the first up on its horizontal stand.

• Aerojet-General's Sacramento Plant announced the successful static firing of another very large segmented solid rocket—this one $8^1/_4$-ft across and 30-ft long, weighing 55 tons and producing a half-million pounds of thrust. Previous two motors in the program weighed 20 and 25 tons.

• Large solids look good in many ways, but a recent evaluation of what you need for Nova first stage in solids points to a booster about half the size of the Empire State Building.

• Speaking of both large solids and liquids, it looks as if they will require some method of off-shore launching or an otherwise isolated launch site, because of the great noise and vibration they will generate. You could probably break all the windows in Miami by launching a Nova from the Cape.

NUCLEAR PROPULSION

• The NASA-AEC Nuclear Propulsion Office announced that the Kiwi-B series of Rover reactor tests would commence this October using gaseous hydrogen as a propellant (see page 25). Cryogenic reactor tests with pumped liquid hydrogen are to begin early in 1962 and to continue at 60-day intervals during the rest of the year under an accelerated test program at Jackass Flats, Nev. NPO is modifying the present test cell at Jackass Flats to use liquid hydrogen, and a second test cell is under construction for this purpose.

• AEC-NASA is negotiating a first-phase contract with Aerojet-General and Westinghouse Electric for development of the Nerva nuclear rocket engine. The contract to run for six months and subject to continuation by the Government includes engine design, schedule of costs, a feasible flight date, and research and development work.

• The AEC hailed as an "unqualified success" the 45-sec test run of the Tory II A-1 reactor, which is being developed for possible application in nuclear ramjet missiles. Tory produced 40 thermal megawatts during the test (equivalent to about 2000 lb of thrust.) It is intended for a power level of 150 megawatts.

• GD-Astronautics and Lockheed Aircraft won six-month study contracts ($112,636 and $128,804, respectively) from NASA's Marshall SFC to study the performance increase in a Saturn booster equipped with nuclear second and third stages. They will define proper engine thrust and investigate funding and scheduling programs.

SPACE TECHNOLOGY

• NASA hopes to orbit its third Tiros weather satellite by July to keep track of Atlantic hurricanes. Tiros III will have two wide-angle camera systems, and drop the narrow-angle system entirely. Congress has been asked to vote NASA an extra $22 million to keep a Tiros in orbit at all times, plus $53 million to the Weather Bureau to prepare for operation of Nimbus, the first operational weather satellite, next year. Meanwhile, NASA reported that Tiros II was still operating after six months in orbit and that it had relayed 31,485 photographs. More than 75% of the pictures were rated "fair to good" for meteorological analysis.

• Echo II (see page 91), the second-generation passive communication reflector satellite, passed its initial inflation tests. The 135-ft rigidized sphere was subjected to a tensile stress of 4000 psi for 4 hr, followed by inflation to destruction at a tensile stress of 18,000 psi. Echo II will be subjected to ballistic flight tests late this year and placed into orbit next year.

• AEC announced that it is setting up recovery facilities at its Hanford, Wash., plant to gather radioactive isotopes for use in nuclear batteries and other devices. Under present plans, it will be able to supply strontium-90, cesium-137, and cerium-144 in megacurie lots by mid-1963.

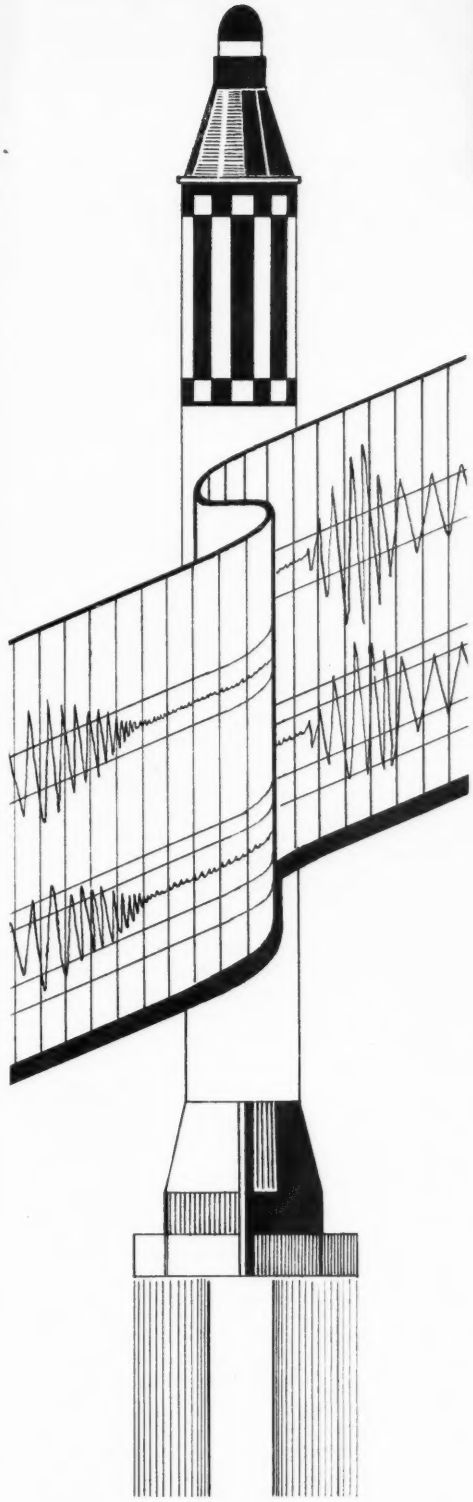
• NASA successfully orbited Explorer XI, the gamma-ray telescope, but a combination of circumstances reduced the flow of data. The tape recorder broke down, so that the satellite can only provide gamma radiation readings in real time to ground tracking stations. At the same time, the satellite's apogee extends to 1104 mi.—well beyond the planned 700 mi. This takes it into the inner radiation belt where its instruments saturate, and there is the further complication that its solar cells may have a reduced life span as a result of particle bombardment.

• The U.S. retired its third rocket booster system last month—the Juno II. The Juno II's last flight was ignominious. As a result of an ignition failure in the upper stages, it dumped its 75-lb S-45 ionosphere beacon satellite into the Atlantic 240 mi. south of St. Johns, Newfoundland. It was the ninth launch for Juno II—four successes (three satellites and the Pioneer IV moon probe) and five failures. The two other vehicles retired by the U.S. are the Vanguard and the Juno I.

• The Naval Ordnance Test Station has designed, developed, and tested a controlled-thrust soft-landing vehicle. The experimental craft is 8 ft high and 5 ft in diam and weighs 700 lb fully loaded and 400 lb without propellants. For background to this NOTS program, see the October 1959 Astronautics, page 37. According to NOTS, its soft lander is the first rocket-powered vehicle to take off and land vertically under its own power.

• NASA issued two major contracts to push the development of its orbiting astronomical observatories, one to GE's Missile and Space Vehicle Dept. for an orientation system and the other to IBM's Federal Systems Div. for an operational-control system, consisting of memory, timers, etc.

• Ballute goes up for testing soon at Holloman and Elgin. The balloon recovery device will perform at greater than Mach 10 and altitudes as high as 155,000 ft. The Cree test vehicle will make launchings at Eglin. For a discussion of Eglin's programs, see page 35.



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• The Pentagon's Advanced Research Projects Agency authorized the USAF Systems Command to negotiate "technological research" contracts with General Dynamics, Hughes Aircraft, and Space Technology Laboratories to study the problems of Ballistic Missile Boost Intercept (Bambi). The work will be financed under the ARPA Defender program to the extent of about $3 million. Infrared detection techniques and satellite-launched defensive missiles figure prominently in Bambi studies

• On its second flight test at Cape Canaveral, the Minuteman solid-propellant ICBM behaved in more normal fashion. Instead of the spooky perfection which characterized the first flight last February, the missile broke down during its second-stage flight and was "destructed" by the range safety officer about 90 sec after launch . . . Also, Atlas E blew up in the first attempt to launch it from a "coffin" bunker at Vandenberg AFB. No one was hurt, but the bunker was destroyed.

• The Air Force reported that Kincheloe AFB, Sault Ste. Marie, Mich., becomes the first of six U.S. bases to be armed with the 400-mi. Bomarc-B interceptor missile. Additional bases for the ramjet-powered, exotic-fuel weapon will be located at Duluth and Niagara to provide overlapping coverage for populous areas of the U.S. and Canada.

• Crackling opinions and a hard-driving approach characterize Defense Secretary Robert McNamara. Here are some samples of his opinions, drawn from recent congressional hearings: The B-52 bomber equipped with Skybolt air-launched ballistic missiles will prove a more efficient weapons system than the Mach-3 B-70 bomber now under development; contrary to Navy claims, it isn't possible to build a feasible anti-satellite weapon in 18 months; few if any Soviet missile submarines can fire these weapons while submerged; and—a flat repudiation of the position taken by the Eisenhower Administration—Soviet posession of very large ICBM boosters is a distinct military advantage. (The bigger they are, for instance, the more decoys you can throw around.)

COMMUNICATION SATELLITES

• The Federal Communications Commission and the Justice Dept. gave their blessing to the formation of a committee of international common carriers for the purpose of establishing a joint venture to manage the communication satellite program. The Justice Dept. agreed to spell out anti-trust guidelines for the interested companies, while the FCC requested that periodic detailed reports be made of the results of the joint-venture discussions.

• Membership in the joint venture committee was not specified at *Astronautics*' press time. FCC ruled tentatively to restrict the joint venture to the international carriers only, throwing out the applications of General Electric (through its subsidiary Communication Satellites, Inc.) and other equipment manufacturers. Inclusion of outside companies would disrupt traditional operational patterns, impede effective regulation, and encumber the system with complicated corporate relationships, FCC held.

• GE promptly petitioned for a reconsideration, and it appeared the FCC might act on the petition by late June, because of the high priority it has assigned the communications satellite program. Meantime, the FCC may commence discussions with RCA, AT&T, ITT, and other carriers.

• NASA picked RCA to develop the 100-lb, solar-powered experimental Relay satellite. It will negotiate a $3,250,000 contract with RCA to build a package capable of relaying 600 voice channels or a single one-way television channel. Relay will be launched in about 1 yr from Cape Canaveral aboard a Thor-Delta booster in an orbit ranging outward to 3000 miles to determine the effects of the Van Allen Belt on the photovoltaic characteristics of the solar cells. Both the French and British governments will participate in the experiments, and will provide suitable ground stations in Europe.

• Promptly on the heels of the Relay award to RCA, NASA notified AT&T it was willing to get down to brass tacks on the provision of boosters at cost to orbit AT&T's privately-financed active satellites. It then appeared that AT&T was no longer in a pressing hurry to get on with its own program.

• This nettled certain high NASA officials, who had been sharply criticized by AT&T for allegedly dragging their feet on the AT&T proposal. But they were ready to work for a quick agreement, particularly since President Kennedy is requesting $50 million in additional funds to expedite the commercial program by having the government sustain some of the development risks.

• The Navy awarded the Bendix Corp. a $670,000 contract to commence engineering of a shipboard terminal for the Army' Advent communication satellite. The 24-hr equatorial Advent will utilize ground stations at Fort Dix, N.J., and Camp Roberts, Calif., plus the mobile shipboard terminal capable of operating in many places of the world.

• A major problem facing the Advent satellite (aside from its weight requirement) is the allocation of sufficient radio spectrum for operation. Although the FCC has tentatively proposed 3000 megacycles of microwave for commercial use, it has balked at making similar space available to the military on the grounds that the military should provide for Advent from its already considerable space allocation.

INTERNATIONAL

• The Russians took their lumps with the Venus probe launched from a parking orbit on Feb. 12 Although the 250-ft dish at Jondrell Bank was pressed into service, no contact was made with the probe as it passed the planet.

• Moreover, JPL's Venus radar bounce experiment (see page 81), which gave a figure for the Astronomical Unit so different from that reported by Russian newspapers Tass and Izvestiya as the result of USSR Academy of Sciences work, also came up with a time for the planet's rotation very much at variance with the one reported by the Soviets of 10 or 11 days. The JPL experiment gives a period near that of Venus' 225-day year. So long a period implies a hot, dry, rugged terrain veiled by that softly radiant atmosphere . . . Honor to the Greeks.

• Late in May, meeting in Geneva, the executive committee of the World Meteorological Organization, a special agency of the United Nations, produced what may be the first real step toward international cooperation in the peaceful uses of space. At this meeting the Russians discarded their previous defensiveness about the U.S. weather-satellite program, and showed interest in cooperating with this and other countries involved in setting up a worldwide system to gather and distribute weather data. ♦♦

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On the calendar

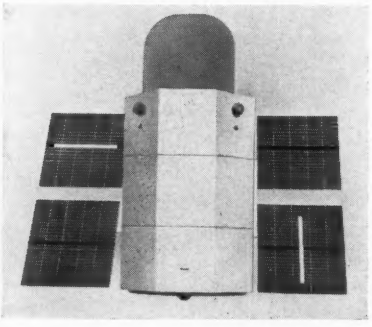
1961

July 5–8	AEC First International Univ. of California Materials Conference, Univ. of California, Berkeley.
July 9–14	4th International Conference on Bio-Medical Electronics and 14th Conference on Electronic Techniques in Medicine and Biology, Waldorf-Astoria Hotel, New York, N.Y.
July 10–Aug. 4	1961 Summer Institute in Dynamical Astronomy sponsored by Yale Univ. Observatory, Univ. of Arizona, and NSF, at Univ. of Arizona, Tuscon, Ariz.
July 18–19	47th Air Force-Industry Conference, Mission Inn, Riverside, Calif.
July 31–Aug. 11	Conference on Physics of the Solar System and Re-entry Dynamics, sponsored by NSF and NASA-Langley, at Virginia Polytechnic Institute, Blacksburg, Va.
Aug. 1–3	4th Western Regional Meeting of American Astronautical Society, Sheraton-Palace Hotel, San Francisco, Calif.
Aug. 7–9	**ARS Guidance, Control, and Navigation Conference, Stanford Univ., Palo Alto, Calif.**
Aug. 14–22	Modern Developments in Heat Transfer special summer course, Univ. of Minnesota, Duluth, Minn.
Aug. 15–17	1961 Cryogenic Engineering Conference, Univ. of Michigan, Ann Arbor, Mich.
Aug. 16–18	**ARS International Hypersonics Conference, MIT, Cambridge, Mass.**
Aug. 23–25	**ARS Biennial Gas Dynamics Symposium, Northwestern Univ., Evanston, Ill.**
Aug. 28–Sept. 1	International Symposium on Rockets and Astronautics sponsored by Japanese Rocket Society, Tokyo.
Aug. 28–Sept. 1	International Heat Transfer Conference, Univ. of Colorado, Boulder, Colo.
Sept. 6–8	IRE National Symposium on Space Electronics and Telemetry, Albuquerque, N.M.
Sept. 7–8	1961 Fall Meeting of Western States Section/The Combustion Institute, Univ. of California, Berkeley, Calif.
Oct. 2–4	Seventh National Communications Symposium of IRE Professional Group on Communications Systems, Municipal Auditorium and Hotel Utica, Utica, N.Y.
Oct. 2–7	**XIIth International Astronautical Congress, Washington, D.C.**
Oct. 4–6	American Society of Photogrammetry Semi-Annual Convention, Biltmore Hotel, New York, N.Y.
Oct. 9–15	**ARS SPACE FLIGHT REPORT TO THE NATION, New York Coliseum, New York, N.Y.**
Nov. 12–17	Conference on Medical and Biological Problems in Space Flight, Nassau, Bahamas.

1962

Jan. 24–26	ASME Thermophysical Properties Symposium, Princeton Univ., Princeton, N.J.

ASTRONOMICAL SATELLITE



National Aeronautics and Space Administration's Astronomical Observatory will be launched 500 miles into space in 1963. It will orbit above the screen of Earth's atmosphere, which distorts and absorbs radiation from stellar objects. Observations through a 36 inch telescope from this vantage point will provide astronomical data unavailable from any ground-based equipment.

Initial Stabilization—Within five hours after reaching orbit, the Astronomical Satellite's stabilization and control system will eliminate tumbling and roll, and orient its optical axis away from the sun. Reference to a predetermined star pattern will verify initial stabilization.

Accurate Stabilization—Next, the satellite will be pointed and held to within 1.0 minute of arc, using feedback from the system's six star-trackers. Feedback from experimental optics will then be used to stabilize the satellite within 0.1 seconds of arc.

General Electric's Missile and Space Vehicle Department is developing the stabilization and control system for the Astronomical Satellite. Similar systems for Atlas and Thor re-entry vehicles, and Advent and Nimbus satellites have already been designed by MSVD . . . a department of the G.E. Defense Electronics Division. 160-09

GENERAL ELECTRIC

ASTRONOMICAL SATELLITE will orbit beyond Earth's atmospheric haze—historic barrier to man's study of stars. Once this NASA satellite is stabilized in orbit, its ground-controlled telescopic and electronic equipment can automatically observe, collect and transmit data. The control and stabilization system for this orbiting astronomical observatory is being developed by General Electric's Missile and Space Vehicle Department for Grumman Aircraft Engineering Corporation, prime contractor for the Astronomical Satellite.

GENERAL ELECTRIC

MISSILE AND SPACE VEHICLE DEPARTMENT, PHILADELPHIA, PA.

For the record

The month's news in review

May 3—Titan test vehicle successfully launched from 146-ft-deep silo in first attempt.

May 4—Two Navy balloonists soar to record 21.5-mi. mark. Comdr. Victor Prather, medical officer aboard, killed by fall from helicopter sling while being picked up from Gulf of Mexico.

—House space committee restores $126 million to space budget for FY '62.

May 5—U.S. Astronaut Alan Shepard travels 115 mi. into space and 302 mi. out to sea in 15 min. in Mercury-Redstone flight.

May 6—Jodrell Bank says its experiments show that the planets are one foot a mile farther from earth than previously calculated.

—Theodore von Karman feted by space community on his 80th birthday.

May 8—Army announces it will buy French-designed Entac antitank guided missiles.

May 10—USSR Cosmonaut Maj. Yuri A. Gagarin discloses he landed in his spaceship after orbital flight on April 12.

May 12—Soviet radar studies give Astronomical Unit of 92,812,797 mi., plus or minus 3205 mi., whereas JPL derives a figure of 92,956,000 mi., plus or minus 621 mi.

May 14—Tory II-A-1 nuclear engine static-tested for 45 sec at AEC's Jackass Flats proving grounds.

May 15—GE plug-nozzle engine develops 50,000-lb thrust during test-firing.

May 18—NASA selects RCA to build Project Relay experimental communications satellite.

May 19—Second flight-test Minuteman destructed 90 sec after launch.

—NASA lets study contract to Martin Co. "to investigate various methods of manned transportation between the earth and the moon."

—Soviet Academy of Sciences elects Mstislav V. Keldysh as president.

May 24—FCC endorses plan for a commercial communications satellite system to be owned jointly by worldwide telephone and telegraph carriers.

May 25—President Kennedy urges nation to get behind race into space, calls for increased expenditures over next five years to put a man on the moon.

—X-15, piloted by NASA's Joe Walker, sets speed mark of 3307 mph.

May 26—B-58 Hustler makes record flight from N.Y. to Paris in 38 hr, 19 min, 41 sec, averaging 1050 mph.

May 28—Soviet scientists report taking first rocket pictures of a solar eclipse (Feb. 15).

May 31—NASA reveals its scientists have simulated a free-flight speed of just under 30,000 mph at its Ames Research Center.

—Explorer XI miniature timing device successfully switches radio frequencies.

Mail bag

On Practical Communication Satellites

Gentlemen:

In their paper "Communication Satellites—How High?" (see this issue, of *Astronautics* page 42) G. E. Mueller, W. B. Hebenstreit, and E. R. Spangler raise a lot of important issues concerning optimum altitudes for communication satellites, but I don't believe that they resolve them. Nor need the issues be resolved at this time. If we are to have a useful satellite system soon, what we need first are experimental results on which to base paper studies, and paper studies had best wait on the experimental results.

We need more and better data on the effect of delay and echo suppressors on telephone conversations.

We need further data on radiation in the Van Allen belts, whose magnitude is still imperfectly known.

We need an actual, physical, not a hypothetical attitude-control system which evaluation on the ground shows to have a good chance of lasting several years. People have been talking about the desirability of such a thing for years but it will remain idle to speculate about its use until we have it and know something about it.

We need a simple but realistic experimental active satellite which will demonstrate, *contrary to most satellite experience*, that a satisfactory life can be attained in satellite electronics.

In writing this letter, I haven't had time to check figures in detail. I will note that the important thing concerning a solar cell is how long it takes for the efficiency of a reasonably shielded cell to fall to some specified value. The efficiency plotted vs. the logarithm of the life is nearly linear, so the life increases very rapidly as we accept a lower final efficiency. I don't believe that the authors have shown that operation of a satellite is impractical in the range of altitudes from 1000 to 10,000 mi.

J. R. Pierce
Director of Research, Communications Principles
Bell Telephone Labs, Murray Hill, N. J.

GCR studies and tests prove the reliable Solid Rocket can be happily wed to the Liquid Rocket. Product of this union—the Hybrid Rocket: number of stops and starts practically unlimited; thrust and speed control from 0 to 100 per cent; more specific impulse (I_{sp} and I_{spd}) than any other non-cryogenic system. ■ The Hybrid is particularly well-suited for soft landings on airless celestial bodies, for highly accurate orbital changes of satellites and spacecraft, and for controllable defense missiles. **GRAND CENTRAL ROCKET COMPANY**

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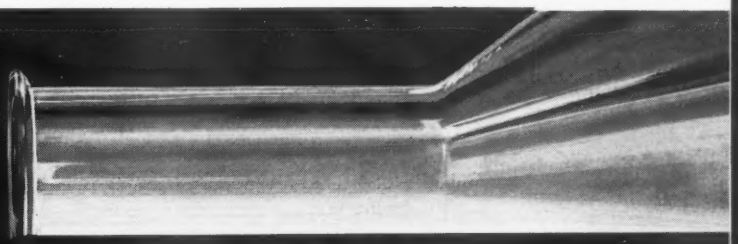


THE MOST PROMISING MARRIAGE IN ROCKETRY

International scene

By Andrew G. Haley

ARGENTINA's foremost space scientist Teofilo M. Tabanera has just completed visits in Washington and New York in an effort to set up programs for astronautical research and development in South America. Prof. Tabanera is one of the "immortals" of the International Astronautical Federation (IAF), as he has officiated in every IAF Congress since its inception in Paris in 1950. The list of the immortals includes Leslie R. Shepherd, of the British Interplanetary Society; Leo Hansen, Dansk Interplantarisk Selskab; Ake Hjertstrand, Svenska Interplanetariska Sällskapet; Josef A. Stemmer, secretary of the IAF and president of Schweizerische Astronautische Gesellschaft; Val Cleaver, British Interplanetary Society; Eugene Sänger, Deutsche Gesellechaft für Raketentechnik und Raumfahrt, and a few others. Heinz Gartman (DGRR) died during the XIth IAF Congress in Stockholm.

Prof. Tabanera is chairman of the Commission on Astronautics which was officially organized by the Argentine government. As chairman, Tabanera summomed the first Inter-American Symposium on Space Research to meet in Buenos Aires Nov. 28 to Dec. 3, 1960. The conference was surprisingly well-attended by scientists from most of the countries of North and South America. The senior members of the large United States delegation included Hugh L. Dryden and Richard W. Porter. At the conclusion of the conference, "Declarations of Buenos" were adopted setting up the framework for a permanent Inter-American organization (see *Astronautics*, February 1961 issue).

Prof. Tabanera plans to call another meeting of the Inter-American Committee for Space Research to be held in Washington during the XIIth Congress of the IAF Oct. 2-7, 1961. He also hopes at that time to effectuate a program of research and development for South America.

It is no secret that many persons, other than Tabanera, are highly interested in this same sort of project. Arnold W. Frutkin, director of the Office of International Programs, National Aeronautics and Space Administration, has just returned from a highly significant survey of South America. The details of his mission have not been released but because of his well-known executive capacity, diligence and dedication to the cause of astronautics, it may be expected that significant action will flow from his visit. The well-known interest of Dr. Dryden in encouraging research and development throughout the world for peaceful uses of outer space greatly enhance the possibility of a NASA-supported project of development in Latin America.

It is also no secret that Theodore von Karman, chairman, Advisory Group for Aeronautical Research and Development (AGARD) of NATO, and chairman emeritus of the Scientific Advisory Board of the Chief of Staff, United States Air Force, is intensely interested in the establishment of a "civilian" AGARD for Latin America. His viewpoints have attracted support from highly significant industrial organizations such as General Motors.

Dr. von Karman and some of his associates have taken another highly significant step in the advancement of international cooperation by organizing in Washington *The Astronautics Foundation, Inc.* Residents of the U.S., including individuals and all forms of legal entities other than nonprofit organizations, may not make tax exempt contributions to non-U.S. institutions or activities. Now, however, a U.S. resident, whether an individual or a corporation, may contribute to the Astronautics Foundation on a tax exempt basis and the Foundation in turn may support such enterprises as the International Academy of Astronautics.

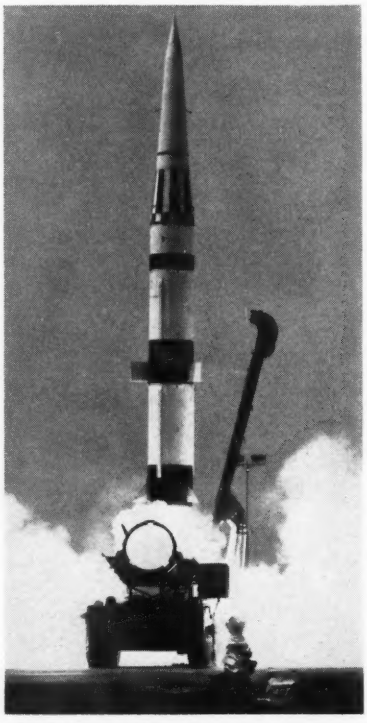
Delegations to attend the XIIth International Astronautical Congress meeting in Washington are being organized throughout the world. The Polish delegation will consist of: Michal Lunc, member of the Polish Academy of Science; Mrs. Lunc; Zbigniew Paczowski; Henryk Muster; Wladyslaw Fiszdon, member of the Polish Academy of Science; Zbigniew Jethon; Janusz Thor; Sylwester Etmanowicz; and Olgierd Wolczek.

Brazil intends to send Thomas Pedro Bun (president of Sociedade Interplanetaria Brasileira), Luiz de Gonzaga Bevilacqua, Flavio Augusto Pereira, Col. Georges Guimaraes, and Emilio Reichart.

The Argentina delegation (Associacion Argentina Interplanetaria) will consist of Aldo A Cocca (president), Teofilo M. Tabanera, Josè O. Martinez, Rogelio Iribarren, and Mayor Norberto Zega.

The indefatigable Ake Hjertstrand (Svenska Interplanetariska Sällskapet) has organized a chartered flight to accommodate one hundred persons; the flight is already fully subscribed. ♦♦

Pershing Coming Up



The latest configuration of the Army's Pershing field ballistic missile, being developed by Martin-Orlando, launches successfully in its first flight test at Cape Canaveral. The new ablative nose cone of the missile employs unusually simple and inexpensive construction, according to its producer, Martin-Baltimore. The newest version of the missile also includes improved solid-propellant motors in both stages. An operational dress rehearsal for the Pershing system will be held this fall.

How the ocean grew "ears" to pinpoint missile shots

A quarter of the world away from its launching pad an experimental missile nose cone splashes into the ocean.

How close has it come to the target?

Where can it be found, recovered and studied?

To answer these questions quickly and accurately, Bell Telephone scientists have developed a special system of deep-sea hydrophones—sensitive "ears" that hear underwater. Its name—the Missile Impact Locating System, or MILS for short. MILS, produced by Western Electric, manufacturing and supply unit of the Bell System, involves two types of networks.

- One is a Long Distance network which monitors millions of square miles of ocean. The nose cone releases a small bomb which sinks and explodes at optimum depth for transmission of underwater sounds. Vibrations are picked up by hydrophones stationed at optimum depth and instantly carried by cables to ground stations. Since the vibrations take longer to reach some hydrophones than others, time differences are measured to compute the location of the nose cone.
- The other is a "bull's-eye" network which monitors a restricted target area. This network is so sensitive that no bomb is needed. It can detect the mere splash of an arriving nose cone and precisely fix its location.

MILS is now operating in both the Atlantic and the Pacific test ranges. It was installed by the U. S. Navy with technical assistance from Western Electric.

It's still another example of how the universe of sound—below the sea, above the earth, in outer space—is constantly being explored by the Bell Telephone System.

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Where the Money Goes

GROWTH of astronautics and rocketry, during the past few years, has been thrilling; yet it is but a small preview of things to come. The American Rocket Society has worked hard to keep pace with the explosion in space technology and today better serves its members and our country than ever before. Our Society's present health in membership, finance, and activities is good, growing better, yet straining to meet the great challenge of the future. It is to our future needs and the resulting financial implications that I wish to draw your attention.

In 1953, the Society had 2400 pioneer members, published 308 journal pages, and had a total income of about $46,000. In 1961 the ARS will exceed 20,000 members, publish 4000 pages of technical material, and will have an income, spent for its membership, of over $1 million—a remarkable growth for any organization. Today the Society returns about $60 annually in services and publications to each member as compared to less than $20 in 1953 when the dues were increased from $10 to $15.

Where does the money come from and how is it being spent? The American Rocket Society, a nonprofit organization, derives its main income from dues, advertising, and registration and exhibits at meetings. The major dividends are in expanded technical publications (with all members receiving all publications) and in a vigorous meetings program serving the technical specialist, the general public, the government, and, indeed, our country as a whole.

It is with pride that we view these past achievements, but the future needs are great. The growth of space technology has generated a requirement for an expanded literature to provide adequate exchange of technical information. We wish to enlarge further our publications to help meet this demand, in particular, to provide a more effective outlet for engineering achievements related to space science and technology. Still better meetings, prompter preprints and dissemination of information are needed. As the Society grows in membership, its internal operations must be modernized to cope with the growing volume of business and services. The professional staff must be enlarged to provide better service to members throughout the country. Student chapters, although nonsupporting, represent a vital investment in the future and must be increased and strengthened.

In 1961, ARS will spend about $1.3 million in servicing its membership—over $60 per member. In 1964, it is expected that expanded services for an expanded membership will call for over $3 million in expenses.

Intelligent growth requires vision, planning, *and* money. The American Rocket Society has amply demonstrated its vision, and through the endeavors of its staff and Board of Directors has kept ahead with its planning. It is a difficult task to finance a nonprofit organization in a free society. Success will require the best efforts of our members, private industry, and the government. The Society serves them all and it has served them well.

Robert A. Gross
CHAIRMAN, ARS FINANCE COMMITTEE

Entrance—the U.S. lunar program

"It will not be one man going to the moon . . . it will be an entire nation, for all of us must work to put him there"

—President J. F. Kennedy, May 25, 1961

By Henry Simmons

Astronautics CORRESPONDENT, WASHINGTON, D.C.

The great relief—NASA's Mercury-Redstone bearing Astronaut Alan Shepard launches from Cape Canaveral on May 5, beginning its historic 302-mi. ballistic hop down the Atlantic. Shepard's flight built broad public identification with the national space program for the first time, and set the stage for President Kennedy's call for a U.S. expedition to the moon in this decade.

THE National Aeronautics and Space Administration is tackling its biggest job yet: An all-out race with the Russians to land the first manned expedition on the moon.

Long before Congress could act on President Kennedy's dramatic request for $679 million in additional space funds (including $531 million for the manned lunar mission), NASA officials were hard at work on plans to make this goal a reality. NASA sees the first lunar-landing mission as a direct earth-moon-earth space voyage for three men aboard an Apollo-C spacecraft, with provision for a stay of four to six days on the moon's surface.

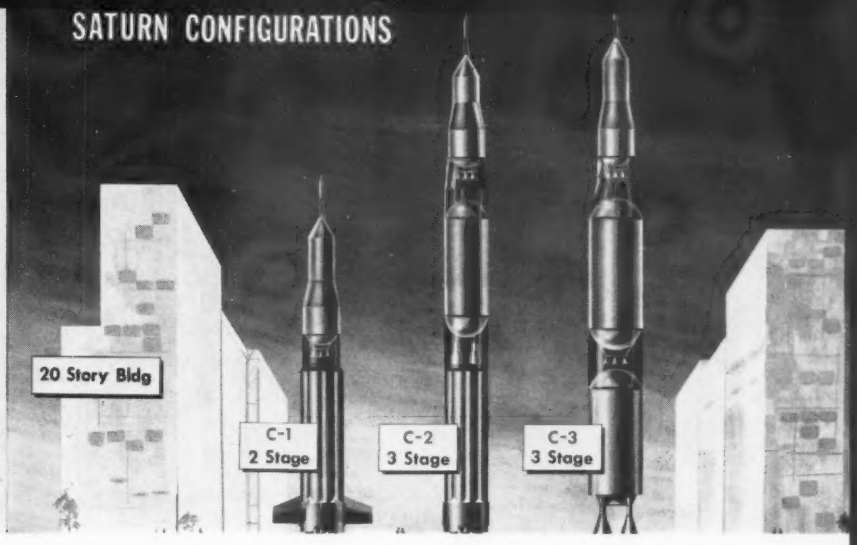
The accomplishment of this task in the present decade—possibly as early as 1967—means that parallel hardware development approaches will be essential. Thus, the Air Force was earmarked $62 million of the new funds to commence development of a solid-propellant version of the Nova booster, while NASA itself requested $144.5 million of the extra money to start work on a liquid-propellant Nova rocket based on the Rocketdyne F-1 engine of 1.5-million-lb thrust from a single chamber.

Other major NASA requests for funds included $130.5 million to accelerate the Apollo program, $66 million for extensive unmanned lunar explorations with Surveyor and Prospector soft-landers to pave the way for the manned landing, $60 million for a new manned space-flight laboratory, and $12 million for development of launch-vehicle technology, including orbital rendezvous as a possible alternative to the Nova approach (See page 104).

In explaining their program to Congress, NASA officials stressed that new funds would support quick steps to obtain the detailed engineering information necessary to "size" the Nova booster and the propulsion modules associated with the Apollo-C spacecraft. Until this data becomes available, it will be impossible to define the lunar-landing mission with any precision.

One of the most troublesome problems is the question of propellant to be used in the two propulsion modules associated with the Apollo-C landing craft. These modules must provide a total velocity increase of 14,000 fps in two equal increments, plus a safety margin of about 15% for each module. If it proves impossible to use cryogenic hydrogen and oxygen propellants on Apollo-C, the Nova booster will have to be increased roughly one-third in size.

An indication of the Nova size was given by NASA Administrator James Webb in a speech at Tulsa, Okla. The rocket would measure



Wernher von Braun, director of NASA's Marshall Space Flight Center, described this pattern of Saturn booster development in a speech recently in Tulsa, Okla. Saturn will launch Apollo orbiting manned laboratories, figure in orbital-rendezvous experiments, boost experimental nuclear rockets into orbit, and engage in other major space missions. Note the absence from the Saturn C-1 of the previously planned Centaur second stage.

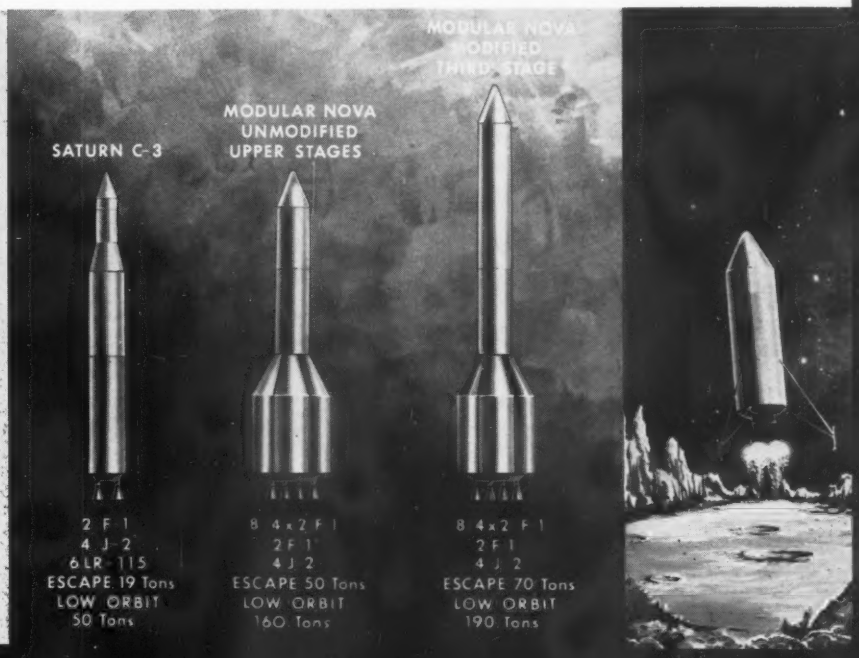
360 ft in height and have eight F-1 engines in the first stage to give 12 million lb of thrust. Together with two upper stages using liquid oxygen and liquid hydrogen, this booster would be capable of propelling a 150,000-lb Apollo assembly to the moon. This load would consist of a deceleration propulsion system (100,000 lb), a propulsion unit to escape the moon for the return to earth (35,000 lb), and the Apollo command and control module with a three-man crew (15,000 lb). The foregoing breakdown assumes the use of low-energy storable propellants instead of high-energy cryogenic combinations. A substantial payload dividend can be realized if the cryogenics can be employed.

Somewhat more amenable to prompt solution were the inevitable organization problems posed by the massive transfusion of funds and personnel proposed by the Administration. It was obvious, for example, that the NASA Space Task Group, now directing Project Mercury, was to be doubled in size, reorganized to handle a bigger assignment, and probably moved to a new location with more elbow room. A name change also seemed certain; its existing designation was too transient to fit the determined U.S. drive for the moon.

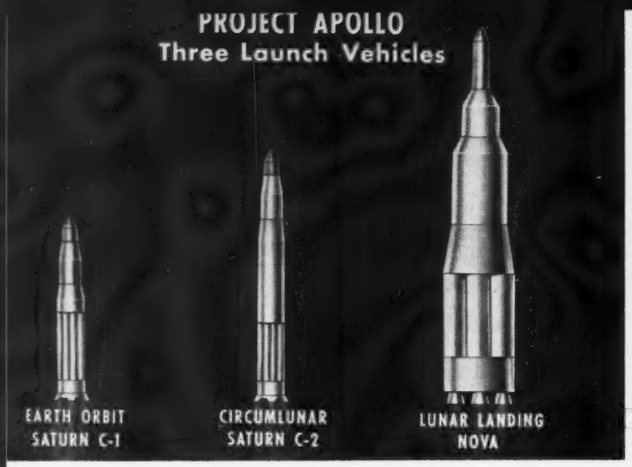
Responsibility Can Be Resolved

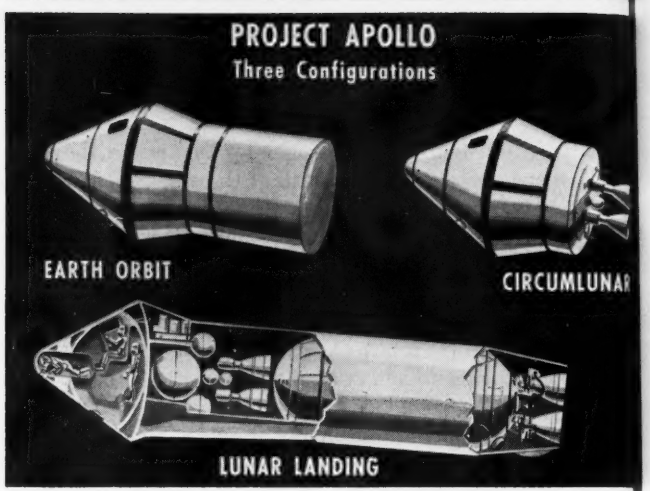
Other organizational questions were more difficult. For example, who would develop the lunar-landing propulsion systems? The Space Task Group may see them as integral portions of the Apollo-C, while NASA's Marshall Space Flight Center could enter a solid claim for the units on the ground they were essentially upper stages of the booster rocket placing the Apollo in its lunar trajectory. But there is no doubt this problem can be resolved in a happy family way.

Peripheral and supporting phases of the lunar



The largest Saturn compares like this with NASA's present view of the Nova concept, represented by two modular vehicles. The largest Nova—which might tower 360 ft high—would make the lunar-landing mission with a three-man Apollo-C spacecraft as payload.





NASA's lunar expedition shapes up like this in present planning. Saturn C-1 orbits Apollo manned orbiting laboratories to train crews and develop equipment. Saturn C-2 boosts exploratory Apollo spacecraft on circumlunar reconnaissance. Nova launches Apollo-C spacecraft for lunar landing and return to earth. The Nova booster may employ either clustered 1.5-million-lb-thrust liquid-propellant F-1 engines or large solid rockets just beginning to be developed.

mission were outlined with relative ease by NASA:

• The last few Mercury capsules will be modified to permit 24-hr manned flights and week-long flights by simians and other animals to gather data on prolonged weightlessness.

• The Surveyor program will be doubled from 7 to 14 landings in the 1963–67 period, and the Prospector will be redesigned to support the landing. It is expected that Surveyor will gather data on lunar surface characteristics for design of the Apollo-C's landing gear, while the mobile Prospector will examine potential landing areas.

• An orbital-rendezvous program using Agena vehicles will parallel the dual approach on the huge Nova booster. This will cover the possibility that Nova cannot be "man-rated" but can be used to orbit the bulk of a lunar vehicle. A Saturn booster could then dock the crew in the spacecraft orbited by the Nova, and the lunar mission could proceed from that point.

• A key feature of the $60 million Manned Space Flight Laboratory will be a giant new centrifuge capable of whirling a three-man cab. No U.S. centrifuge can now do this job, and NASA believes the capability must be developed to train Apollo crews under the most realistic conditions.

The New Frontier's lunar commitment has resulted in a 61% boost in the NASA funds request for fiscal 1962 over the original Eisenhower request of $1,109 million. In two upward revisions, President Kennedy has increased this figure to $1,784 million.

Throwing in the space budgets of the Pentagon ($1,095 million) and the Commerce Department ($53 million for weather satellites), the total U.S. space program amounts to $2,932 million for the next fiscal year.

Long-Term Investment Asked of Nation

Hefty as these sums are, they represent only a start on a great national investment in space exploration. NASA officials have estimated that the first half of the 10-yr lunar program will cost us $5 to $7 billion, and that the total cost to NASA for the balance of this decade could aggregate over $40 billion. Even so, there were early signs that Congress would support the Administration's program of a race for the moon, although the President could offer no positive assurance that the U.S. would win the race.

President Kennedy took pains, in fact, to emphasize the long-term commitment he was asking of the U.S., and he used the most negative language possible:

"While we cannot guarantee that we shall one day be first, we can guarantee that any failure to share this effort will make us last . . . Let it be clear that I am asking the Congress and the country to accept a firm commitment to a new course of action—a course that will last for many years and carry very heavy costs—an estimated $7 to $9 billion additional over the next five years. If we were to go only half way, or to reduce our sights in the face of difficulty, it would be better not to go at all."

In effect, the President committed us not to just a lunar exploration, but to full participation in pushing the new industrial revolution and its focus, astronautics.

Privately, space officials were optimistic that the U.S. could beat the Russians to a manned landing on the moon. They acknowledge that the Russians have a much larger boost capability than the U.S. —probably on the order of 800,000 lb of first-stage thrust to orbit the 5-ton spaceships and the 7-ton "station" from which the Venus probe was launched. But they maintain that this propulsion capability—even if it existed in a single thrust unit instead of several—would not give the Russians any advantage in developing a Nova-type vehicle for a direct flight to the moon. For that, an F-1 sized thrust unit or larger is necessary.

In other words, the Russians will have to embark on a Nova vehicle of their own if they are seriously interested in racing the U.S. to the moon. Whether they have in fact started such a project is not known, but U.S. space officials are confident that we have a far-better chance of beating the Russians in this race than in lesser space competitions based on present boosters and coming ones up through the Saturn class.

"By taking this goal of landing on the moon, which is a very considerable number of years away, we start more evenly with the Russians, so that we do have a chance of getting there first," declared Hugh Dryden, NASA Deputy Administrator. ♦♦

NASA illustration depicts separation of the Saturn C-1 booster from an Apollo manned laboratory on its way into earth orbit.

George Low, director of NASA's Space Task Group, recently described this alternative to the "tail-down," vertical approach to lunar landing with the Apollo spacecraft. Unmanned Prospector vehicles might evaluate both landing maneuvers.

Nuclear rockets and the space challenge

The nuclear rocket can not only assure us of being first in the race to the near planets, but also, if developed early enough, can provide insurance for our U.S. program to put a man on the moon before 1970

By Harold B. Finger

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C.

Harold Finger has been chief of NASA's nuclear engine program since the agency was established in 1958, and is now assistant director for nuclear applications in NASA's Office of Launch Vehicle Programs and manager of the joint AEC-NASA Space Nuclear Propulsion Office. He has been with NASA and its predecessor organization, NACA, since 1944, serving as an aeronautical research scientist (1944–52), head of the axial flow compressor section (1952–54), and associate chief of the compressor research branch (1954–58) at the NACA Lewis Laboratory before joining NASA headquarters in 1958, and doing research on turbomachinery, nuclear rockets, and shielding.

This article is based on a talk presented at the ARS Space-Nuclear Conference, May 3, 1961, at Oak Ridge National Laboratory, Gatlinburg, Tenn.

As HAS been pointed out frequently by NASA and other government officials, the Soviet Union has chosen the area of space exploration as the most visible form in which to demonstrate its technological strength. It is using this area of science to win the high technological position that we have held, and thereby to win the support of the world.

We have, as you know, made significant contributions to a scientific understanding of the space environment and to the practical applications of the satellite equipment that we have developed. Our work in these programs has been freely disseminated for the benefit of all. The Pioneer and Explorer series, Tiros, Echo, and Transit are important U.S. contributions in the areas of space sciences and space technology and are areas in which we have the lead.

It is an obvious fact, however, that in terms of manned space flight, we are behind. The Russians have larger vehicles, they have been developing heavy spacecraft, they have orbited a man, they have guided vehicles to an impact of the moon and to a position where they could photograph the back side of the moon. The second satellite they launched in November 1957 (before our *first* satellite), carried Laika, the dog, undoubtedly as part of their manned space-flight program. It was not until a year later, when NASA was established, that we initiated our Mercury program. The Russians must have planned their manned program at least five and a half years ago. Our manned program, and in fact our civilian space program, has been in existence for only three and a half years.

The Russians also started their program with the commanding lead offered by the large ICBM vehicles they had developed. We are still struggling with the small payloads provided by our smaller Atlas vehicle. Not until we have developed the Centaur vehicle will we even come close to Russian orbital payload capability, and not until we have Saturn will we have an orbiting capability greater than the one the Russians have demonstrated.

But obviously we cannot anticipate that the Russians will sit around idly twiddling their thumbs. They are too well motivated for that. We must assume that they will be trying for still greater achievements in space.

Where, then, do we direct our space efforts in trying to accept the challenge? Several approaches are possible. We could launch an

all-out effort to achieve a manned lunar landing as early as possible in this decade in order to try to beat the Soviet Union in that mission (see page 20). Or, on the other hand, we may determine that we should devote our major emphasis to manned Mars and Venus missions and perform the manned lunar landing whenever that becomes possible, using the technology we develop for the planetary missions. A third alternative would call for carrying on with large lunar and planetary programs simultaneously.

Although it could not be done in this decade, perhaps we must aim our program for Mars and Venus. We may not beat the Soviet Union to manned lunar landings because of their head start, but we should be able to plan a program to beat them to the planets. Our program would, therefore, be a long-range one with the moon as a preliminary objective and the near planets as our ultimate objective. Under these circumstances, the nuclear rocket system would have to be our major propulsion development.

In fact, our nuclear rocket program is being conducted with the requirements of planetary missions in mind. I am convinced that our program will provide us with the nuclear rocket technology for planetary missions and that, with sufficient support, it will almost automatically provide us with the capability to perform the lunar-landing mission and with the technology required to provide for extensive manned lunar operations such as will be required, in time, when bases are established on the moon. We believe that we are ahead of the Russians in the development of nuclear propulsion systems and we therefore believe that we can beat them in the long-range space program. To indicate the importance of the nuclear rocket in such a long-term program, I would like to review the results of some of the vehicle analyses that we have conducted for Mars and lunar missions.

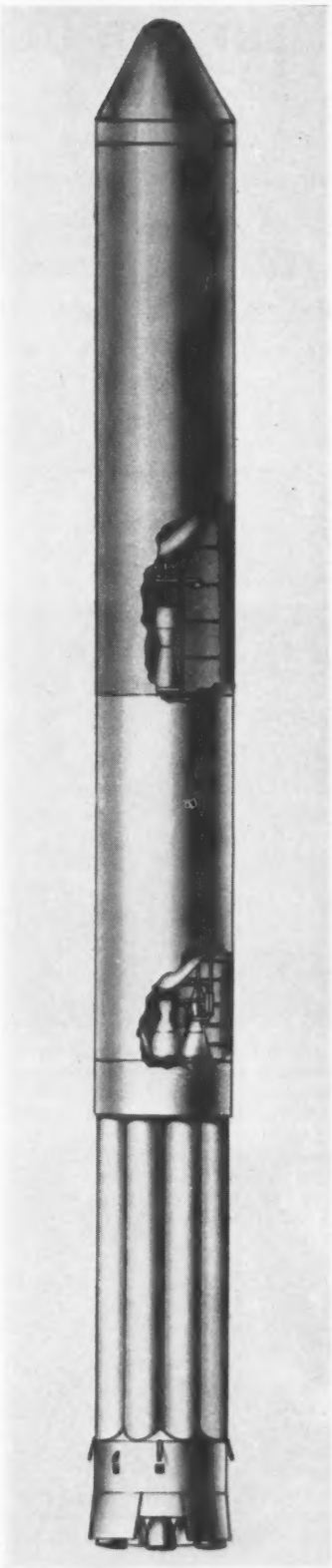
We Seem to be on the Right Track

Obviously we cannot at this time accurately and definitely specify the requirements of a manned Mars mission. However, we have made calculations to give us an indication of the types of systems that would be required for such missions. A detailed specification will require the accumulation of considerably more information on the space environment, the mechanics of flight to the planets, the technology of guidance, propulsion, and vehicle design, and the operation of both man and machine in space. Our calculations have indicated that the performance of the manned Martian mission with all-chemical combustion rocket systems would require the assembly in an earth orbit of a spacecraft weighing 9 to 10 million lb. Although this is theoretically conceivable, I believe that, from practical considerations, it is not feasible.

There is universal scientific agreement that the performance of this kind of a manned Mars mission will require the use of nuclear energy for propulsion. Although chemical combustion systems will still play a role in placing the necessary parts of the spacecraft into orbit and in performing the maneuver of landing on the planet from an orbit around Mars and then returning to the orbiting spacecraft, nuclear energy will provide the propulsive power for the major portion of the mission.

In comparison with the chemically-propelled spacecraft, a nuclear-rocket spacecraft would weigh 900,000 to 1,000,000 lb — one-tenth the size of the chemical vehicle. It (CONTINUED ON PAGE 94)

SATURN WITH NUCLEAR UPPER STAGE



Bringing in electrical propulsion

By clearly defining our objectives and accelerating our efforts in this important field, we can avoid the embarrassment of an "electric gap" in coming space exploration

By Capt. Richard J. Hayes, USAF

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C.

Richard J. Hayes, a captain in the Air Force, is assigned as a technical specialist on electrical propulsion in NASA's Office of Launch Vehicle Programs. After receiving a B.S. in mechanical engineering from MIT in 1954, he became a jet-fighter pilot and was assigned to ARDC as a research engineer and pilot. In 1958 Captain Hayes was selected to attend a graduate program in astronautics at MIT under Air Force sponsorship. In June 1960 he was awarded an M.S. in aeronautics and astronautics from MIT, and was subsequently assigned to NASA. He and two co-authors won the ARS-Thiokol 1960 Annual Award for the outstanding graduate student paper in the field of astronautics—"The Duoplasmatron Ion Rocket."

The opinions expressed in this article, the author notes, are his own and do not necessarily reflect official views of NASA.

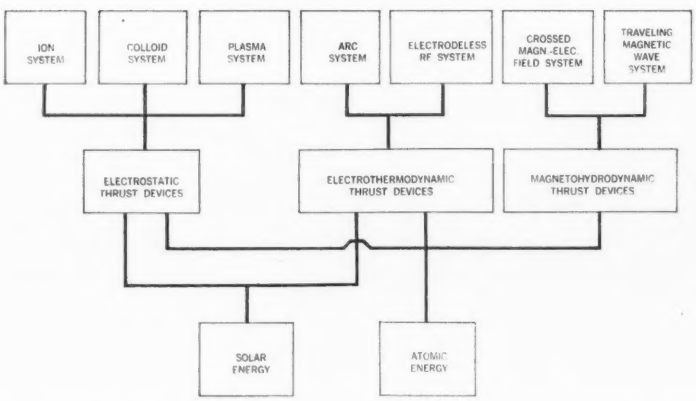
THE U. S. electrical-propulsion program has been described in terms that tend to extremes—on the one hand as an aggressive research effort and on the other as a shockingly inadequate development program. The time may be drawing short in which to give our electrical-propulsion program better definition.

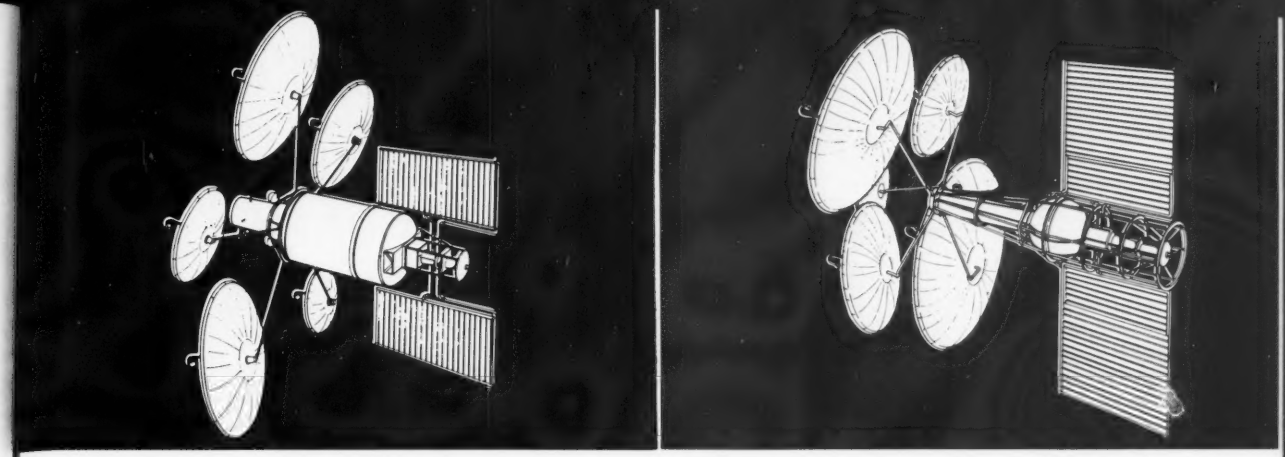
Recently we have become aware of Soviet activity in electrical propulsion; and, although we do not know the exact status of the Russian effort, there are indications that we may have underestimated the scope of their long-range space-propulsion program.

Electrical propulsion has certainly not been a very large item in our space budget, despite the fact that there are many government and industry groups actively engaged in appropriate component research and development. With knowledge of Soviet work on electrical propulsion, can we afford to keep our own effort in this area a relatively minor one? There are good reasons to think we should not, especially when we have done so much good preparation for a fast-moving development program, and have a real expectation to establish an important "first" here—the application of a true space engine.

Where does electrical propulsion fit in the rocket spectrum? When can we make it most useful to our space programs? To answer these questions, we must look at our broad preparations for a

Principal Electrical-Propulsion Systems Under Study





Avco-RAD study sketches of configuration for Snap-8-powered arc-jet system for delivering communications satellite to a 24-hr, stationary orbit. The vehicle on the left employs hydrogen as propellant and the one on the right employs noncryogenic ammonia.

major effort, experimental engines themselves, power supplies, possible missions, and growth potential in this new field.

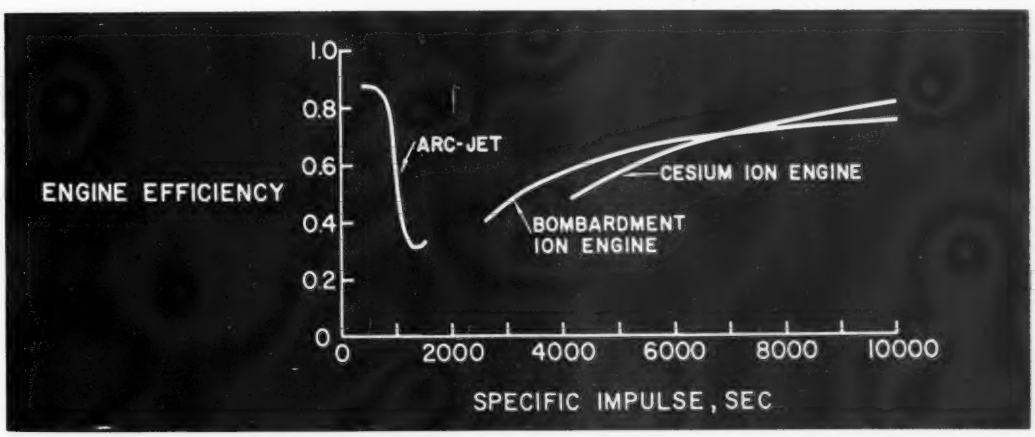
There has been an increasing number of technical papers written on electrical propulsion in the past few years, and many studies have been made to determine possible applications for this new type of propulsion. These include studies by the NASA centers—Lewis, Goddard, JPL, and Marshall. Also, application studies are being performed under NASA contract at United Aircraft, Avco, and General Electric. The Air Force also has a program to develop electric engines. Mission studies for electrical-propulsion systems have been performed under AF sponsorship at GE and Thompson Ramo Wooldridge. Presently, Lockheed Missiles and Space Co. is completing an optimum-trajectory analysis on electrical-propulsion devices for the AF. Also Grumman Aircraft is developing an optimum-low-thrust computer program for electric engines under contract from NASA's Marshall SFC.

In addition, practically every major aviation and propulsion company in the country has done some mission analysis that shows the range of applicability and potential of electrical propulsion. The number of mission studies alone suggests an increasing interest in the use of electrical propulsion for space travel.

Common Denominator—Electric Power Supply

Electrically propelled spacecraft all share one formidable problem—an electric power supply. It has often been stated that the development of a high-powered, lightweight nuclear reactor with a long operating time would increase the pace of electrical-propulsion development in this country. Most mission analyses indicate that a 300-kw nuclear-electric system weighing around 3000 lb would be very useful as an upper stage for the Centaur or Saturn vehicles (for example, see "Applications of Electric Pro- (CONTINUED ON PAGE 103)

Engine Efficiency Summary



Space Flight Report to the Nation Interim Report

New York gets the word on SFRN

200 civic leaders and executives from business, industry, labor, education, the press, and local hotels hear von Braun at luncheon

By Rod Hohl

ARS MEETINGS MANAGER

COMPLETE program details on the ARS SPACE FLIGHT REPORT TO THE NATION were disclosed by Wernher von Braun, SFRN Committee Chairman, before a luncheon audience in the Hotel Biltmore of more than 200 New Yorkers representing a variety of industrial, professional, governmental, and educational organizations.

The SPACE FLIGHT REPORT TO THE NATION, to be held October 9–15 at the N.Y. Coliseum, will afford scientists, engineers, and the general public an opportunity to see and hear for the first time the complete story of U.S. progress in the exploration of space.

Recounting the present position of the U.S. in the struggle for space supremacy, Dr. von Braun declared that "since October, 1957, we have found ourselves in a race for space with the Russians, whether we like it or not.

"We are in a race for new insights, scientific insights into the mystery of the world surrounding our earth and atmosphere—and it is also a race for military stature in this new environment.

"A question that many people ask today is, Are we ahead of the Russians? I think the true answer is that we are ahead in some fields and they are ahead in others.

"The only field in which the Russians have a significant lead in the space program is the area of large boosters. They have consistently lofted heavier payloads into orbit and into outer space than we have. Our shortcomings in this direction are my business as director of the George C. Marshall Space Flight Center."

It is time, Dr. von Braun said, for the American people to take a good look at the United States' space-flight progress. Until now, an opportunity to see and hear the whole story has been lacking. For this reason, he said, the American Rocket Society has taken the lead, in cooperation with government and military agencies, educational and scientific institutions, and industrial companies, to make available the information the public needs and wants.

The SPACE FLIGHT REPORT TO THE NATION, as described by Dr. von Braun, will be primarily a scientific and engineering program. During the five days of the meeting, more than 200

Part of the audience of more than 200 prominent New Yorkers who heard Wernher von Braun and other members of the SFRN Committee provide full details of the October meeting.

ARS SPACE FLIGHT REPORT TO THE NATION

OCTOBER 9-15, 1961

Session Outline

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
MORNING	**Robot Exploration** (Jack Froehlich) **Structures and Materials** (Ernest E. Sechler) **Nuclear Propulsion Test Facilities** (Gaylord Newton) **Logistics and Operational Problems of Very Large Booster Systems** (Phillip F. Fahey) **Power Sources for Electric Propulsion** (John Evvard) **Astrodynamics** (Victor Szebehely)	**Hypersonic Heat Transfer and Vaporization Ablation** (C. F. Hansen) **Human Factors and Bioastronautics** (Col. John Talbot) **Nuclear Instrumentation** (Andrew M. Koonce) **Power Systems** (Major W. G. Alexander) **Electrothermal and Electromagnetic Thrust Generation** (Mark Ghai) **Missiles and Space Vehicles** (Robert Demoret)	**Hypersonics** (William H. Dorrance) **Communication Satellite Future Programs** (Michael Vallard) **Missiles and Space Vehicles** (Robert Demoret) **Liquid Rockets** (Martin Goldsmith) **Electric Propulsion Missions** (Capt. Richard Hayes) **Environment of Space** (Herbert Friedman)	**Ramjets** (William H. Avery) **Missiles and Space Vehicles** (Robert Demoret) **Space Propulsion and Components** (H. G. Jones) **Advanced Guidance Devices** (Charles E. Durham) **Environment of Space** (Herbert Friedman) **Design of Electric Propulsion Spacecraft** (Geoffrey Robillard)	**Propellant Technology for Space Application** (Gerald Morrell) **Magnetohydrodynamics** (Milton M. Slawsky) **Space Law and Sociology** (Andrew G. Haley) **Solid Rockets** (A. Scurlock) **Environment of Space** (Herbert Friedman) **Guidance and Control** (Charles E. Durham)	SPACE EDUCATION DAY	FINAL DAY OF EXHIBITS
AFTERNOON	**Instrumentation for Manned Space Flights** (Col. John P. Stapp) **Structures and Materials** (Ernest E. Sechler) **Nuclear Rocket Mission Studies** (Robert Bussard) **Current State-of-the-Art of Missile and Space Vehicle Flight Testing** (Lt. Col. P. B. Peabody) **Electrostatic Thrust Generation** (A. T. Forrester) **Astrodynamics** (Victor Szebehely)	**Human Factors and Bioastronautics** (Brig. Gen. Ted Bedwell, Jr.) **Communication Satellite Current Programs** (Wilbur Davenport) **Power Systems** (U. B. Thomas) **Hypersonics** (Walter R. Warren) **Missiles and Space Vehicles** (Robert Demoret) **Electric Propulsion Testing** (Robert Supp)	Space Flight Report—The Vehicles (Krafft Ehricke)	Space Flight Report—The Missions (Arthur Kantrowitz)	Space Flight Report—The Global Effects (James Doolittle)		
EVENING	**The History of Liquid Rockets** (A. J. Kelly) **Electric Propulsion Panel** (Ernst Stuhlinger) **Astrodynamics** (Robert M. L. Baker, Jr.)	**Human Factors Panel** (Eugene B. Konecci) **Space Law and Sociology** (Andrew G. Haley) **Power Systems** (John Huth)	USSR Space Program Review	US Space Program Review	BANQUET		

Session Chairmen denoted by parentheses ( )

Head table at the SFRN luncheon at the Biltmore. Left to right, James J. Harford, Robert A. Gross, Gen. John B. Medaris, Commissioner Robert Watt, G. Edward Pendray, Wernher von Braun, Mrs. Robert H. Goodard, Harry Guggenheim, and Jerry Grey.

technical papers will be delivered by space scientists and engineers in some 45 technical sessions, outlining for fellow scientists and engineers the most significant work now being done in the rocket, missile, and space-flight field.

However, during the evening hours, and on the weekend of October 14 and 15, the Coliseum will be opened to the general public to view the host of exhibits of rockets and components which will occupy three full floors of the Coliseum, and to hear popular lectures and panel discussions by the leaders of the American space-flight program. In addition there will be nationally televised programs on the significant Russian advances, as compared with U.S. advances.

Dr. von Braun also told the audience about the special "Space Flight Reports," to be participated in by panels of experts, and designed to bring the country up to date on space vehicles, space missions, and the global aspects of space flight. The moderators will be Krafft Ehricke, manager of Project Centaur at GD/Astronautics; Arthur Kantrowitz, vice president of Avco Corp.; and James Doolittle, chairman of the Board of Space Technology Laboratories, Inc.

An important part of the SPACE FLIGHT REPORT TO THE NATION will be the exhibits, which will enable the audience to see the actual "hardware" of the space-flight program. The principal display will be a spectacular exhibit by the National Aeronautics and Space Administration and the Dept. of Defense, featuring full-size space rockets and the Mercury capsule. In addition, some 300 industrial companies engaged in production for the space program, including many of the country's largest corporations, will exhibit the materials they are supplying toward U.S. space exploration.

Joining with Dr. von Braun in the SFRN luncheon program were Jerry Grey of the faculty of the Daniel and Florence Guggenheim Jet Propulsion Center at Princeton Univ. and James J. Harford, executive secretary of the American Rocket Society.

Dr. Grey, who heads the committee on the Space Flight Report panels, described the program for these panels at the luncheon while Mr. Harford described the arrangements for the meeting at the Coliseum. The SPACE FLIGHT REPORT TO THE NATION will be one of the most important scientific meetings ever held at the Coliseum, and to make it possible, the upper floor of the Coliseum will be materially changed.

The fourth floor will be transformed into several meeting rooms, where a number of technical sessions can be carried on simultaneously. A large lounge will be provided for personal post-mortems on the technical sessions. Technical luncheons will be held on the third floor, where a press room will also be provided.

Television programs will originate from the main floor, in a booth being constructed for the purpose, where the public will be able to witness the proceedings.

On the dais at the luncheon, in addition to Messrs. Harford, Grey, and von Braun, were Harry F. Guggenheim, president of the Daniel and Florence Guggenheim Foundation; Mrs. Robert H. Goddard, widow of the famous American rocket and space pioneer; Maj. Gen. John B. Medaris, formerly head of the Army Ballistic Missile Agency (ABMA) and now president of the Lionel Corp.; Robert Gross, of Columbia Univ. rocket authority and member of the American Rocket Society's Board of Directors; and Commissioner Robert Watt, of the New York City Dept. of Commerce and Public Events, who pledged the full support and cooperation of the city in the projects. G. Edward Pendray, head of Pendray & Co. and an ARS founding member, presided at the luncheon.

The complete program of the SFRN sessions is listed on the previous page. ♦♦

SFRN Committee Chairman Wernher von Braun looks pensive as he ponders a question at the luncheon.

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ARS Space Flight Report to the Nation

OCTOBER 9—15, 1961

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Miss Sylvia Peltonen, Secretary
ARS Housing Committee
90 East 42 Street
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ABBEY, 151 West 51st St.	8.00- 9.00	10.50-12.50	12.50-14.50
*BARBIZON-PLAZA, 106 Central Pk. So.	13.50-15.50		17.50-21.50
*BARCLAY, 111 East 48th St.	15.50-21.50		23.50-27.50
*BELMONT PLAZA, Lexington Ave. & 49th St.	8.50-16.00	14.00-19.00	16.00-20.00
*BILTMORE, Madison Ave. & 43rd St.	8.00-20.00	15.00-25.00	15.00-25.00
*COMMODORE, Lexington Ave. & 42nd St.	8.50-16.50	14.00-20.50	15.00-23.00
*DIXIE, 250 W. 43rd St.	9.00-12.00	12.00-15.00	13.00-17.00
*EDISON, 228 W. 47th St.	8.00-11.00	13.00-18.00	15.00-21.00
*ESSEX HOUSE, 160 Central Park So.	All Space Reserved		
*GOVERNOR CLINTON, 7th Ave. & 31st St.	10.00-14.00	14.00-20.00	14.00-20.00
*HENRY HUDSON, 353 W. 57th St.	8.00-11.00	12.00-16.00	13.00-18.50
*MANGER VANDERBILT, Park Ave. & 34th St.	8.50-21.00	13.00-21.00	15.50-21.00
*MANHATTAN, 8th Ave. & 44th St.	9.00-14.00	14.00-18.00	15.00-18.50
*MAYFLOWER, Central Pk. W. & 61st St.	12.00-16.00		14.00-17.50
NEW YORKER, 8th Ave. & 34th St.	8.00-14.50	11.50-18.00	15.50-20.00
PARAMOUNT 235 West 46th St.	8.00- 9.00	10.00-12.00	12.00-14.00
PARK LANE, 299 Park Ave.	19.00	24.00	24.00
*PARK-SHERATON, 7th Ave. & 55th St.	11.00-16.00		15.00-20.00
*PIERRE, 2 East 61st St.			24.00-30.00
*PLAZA, 5th Ave. & 59th St.			23.00-30.00
*ROOSEVELT, Madison Ave. & 45th St.	8.50-20.00	13.50-24.00	17.50-25.00
*ST. MORITZ, 50 Central Park So.	13.00-16.00		16.00-20.00
*SAVOY HILTON, 5th Ave. & 58th St.	19.00		23.00
*SHERATON-ATLANTIC, Broadway & 34th St.	9.00-14.00	13.00-17.00	14.00-18.00
*SUMMIT, Lexington & 51st St.	14.00-30.00	16.00-32.00	18.00-34.00
TAFT, 7th Ave. & 50th St.	10.75		17.50
VICTORIA, 7th Ave. & 51st St.	9.00- 9.50	12.50-13.00	14.50-16.00
*WALDORF-ASTORIA, 301 Park Ave.	12.00-20.00	18.00-28.00	18.00-28.00
*WARWICK, 65 West 54th St.	18.00		22.00
*WELLINGTON, 7th Ave. & 55th St.	8.50-12.50	13.00-18.00	13.00-18.00
WOODSTOCK, 127 W. 43rd St.	7.00- 9.00	10.00-14.00	10.00-14.00

Rates subject to 5% New York City tax on hotel rooms. *Suites available. For reservations contact housing bureau.

---CUT ALONG THIS LINE---

Hotel Accommodations Desired. (It is necessary that five choices of hotels be listed below:)

INDICATE APPROXIMATE RATE AS SHOWN IN SCHEDULE		TYPE OF ROOM DESIRED		
CHOICE	HOTEL	SINGLE 1 PERSON	ONE DOUBLE BED— 2 PERSONS	TWIN BEDS 2 PERSONS
1st				
2nd				
3rd				
4th				
5th				

If accommodations are not available at any of the above hotels, reservations will be made at some other suitable hotel.

NAME.....

AFFILIATION.....

ADDRESS (Home/Bus.).....

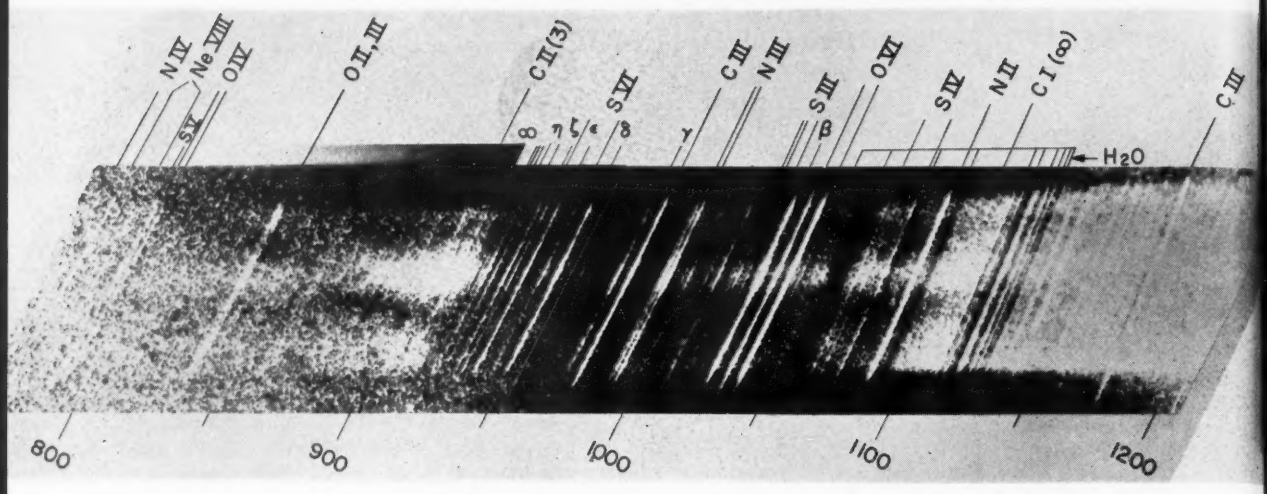
CITY..... STATE.....

DATE ARRIVING..... ARRIVAL HOUR..... DATE DEPARTING.....

Please list names, affiliations and desired accommodations for additional persons on separate sheet and attach to this form.

NOTE: There will be an interval of several weeks before you can expect to receive a direct confirmation from the hotel accepting your reservation. Room numbers cannot be assigned by hotels until guests register on arrival.

MAKE YOUR RESERVATION NOW



The solar spectrum in space

No plan for space operations will be complete without full and exact knowledge of optical solar radiations . . . Rocket research at NRL makes important progress toward this goal

Richard Tousey, head of the rocket spectroscopy branch of NRL's Atmosphere and Astrophysics Div., is the pioneer in the exploration of the sun's radiation in space. His work extends back to 1946 when he obtained the first ultraviolet spectrum of the sun from a V-2 rocket. Tousey received a Ph.D. degree from Harvard in 1933, while working under Theodore Lyman. It is interesting that his space research of recent years has uncovered in the sun many of the emissions discovered in the laboratory by his former professor. Among these are the Lyman series and continuum solar emission of hydrogen (reproduced in this paper), the first detailed photograph of the sun in Lyman alpha, and the first high-resolution profile of solar Lyman alpha. In recognition of this work, Dr. Tousey received the OAS Frederic Ives Medal for 1960.

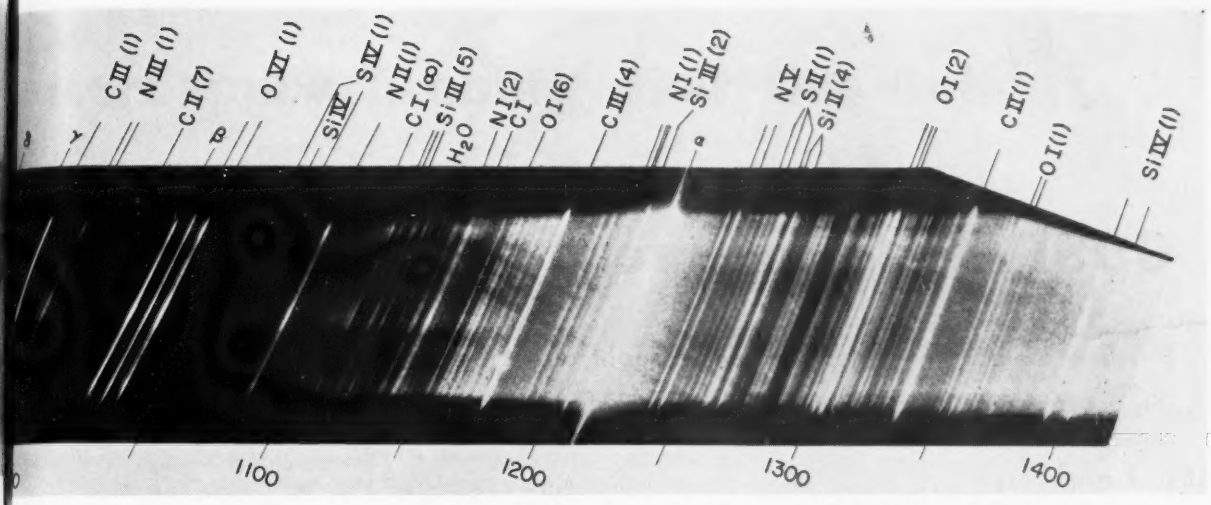
By Richard Tousey

U.S. NAVAL RESEARCH LABORATORY, WASHINGTON, D.C.

THE OPTICAL radiation from the sun is perhaps the most important environmental factor affecting operations in space. To be prepared to solve all the problems of space flight, it is necessary to have a detailed knowledge of the intensity distribution within the solar spectrum, and of the variations that occur in the spectrum from time to time.

Although the ultraviolet below 3000 Å carries only an insignificant 1% of the sun's total radiation, these wavelengths produce important effects whenever they are absorbed. For the astronautical engineer there are many effects to consider. Short-wavelength solar radiation impinging on the metal skin of a vehicle will cause it to become electrically charged. Surface chemical changes may also take place; plastics deteriorate, and glasses discolor, when exposed to ultraviolet and X-rays for long periods of time. Although bursts of X-ray emission, produced by solar flares, will not penetrate sufficiently to be a hazard to passengers, they may serve as warnings of dangerous streams of energetic particles soon to follow.

The space physicist finds a knowledge of the sun's short-wavelength spectrum indispensable to the understanding of the behavior of the earth's upper atmosphere. This is the region where these wavelengths are absorbed, producing many diverse effects—heating, chemical changes, ionization, and the emission of new radiations. From satellite drag data, it is known that the upper atmosphere is heated by absorption of ultraviolet, thus expanding and contracting



The photos left and above, which overlap, show NRL's new record of the extreme ultraviolet. This solar spectrum was taken by rocketborne double-dispersing spectrographs on April 19, 1960—the photo on the left (SC-4 film) between 200 and 220 km, and the one above (DC-3 film) between 148 and 200 km, both with an exposure of 60 sec.

diurnally. Optical measurements offer the possibility of studying atmospheric composition, which must be known if drag data are to be fully and correctly interpreted.

Radio communications, of course, are profoundly affected by changes in the ionosphere, whose several layers are produced mainly by solar ultraviolet and X-rays. Much progress in explaining the behavior of ionospheric layers has been made as a result of new data on the sun, but many problems are not yet solved.

Also, it is now possible to begin to consider the atmospheres of other planets, such as Venus and Jupiter, by assuming atmospheric models. Knowing the composition of the solar spectrum, photochemical and ionization effects can be predicted, and looked for from space vehicles.

To most of us on the earth, weather is probably the most important aspect of the atmosphere. The key to many meteorological problems may well lie in the changes taking place in the high atmosphere, above the levels reached by sounding balloons. Although the solar energy absorbed so high up is small, some meteorologists believe that it exerts a trigger action, and so influences the establishment of weather patterns.

The study of the spectrum throughout the visible, much of the infrared, and a little of the ultraviolet can best be conducted from the earth's surface. The great wavelength range—2900 Å to X-rays—on the other hand, can only be observed from rockets and satellites, because the earth's atmosphere is extremely opaque.

Commencing early in 1946, with V-2 rockets, the U.S. Naval Research Laboratory (NRL) has been engaged in the study of the solar spectrum, from the ultraviolet through the vacuum region and into soft and even rather hard X-rays. Similar programs, conducted by the Geophysics Research Directorate (GRD) of the AF Cambridge Research Laboratories and the Univ. of Colorado, have resulted in data which complement the results of NRL. As a result, the solar spectrum as it impinges on the outermost atmosphere of the earth is now fairly well mapped. There are a great many matters left to be explored, but the first approximation is in hand.

Irregular Nature of the Sun

It is well established that different places on the sun radiate unequally. This has long been known for the visible and near ultraviolet, but here the effect is very small. In the rocket-viewed ultraviolet and X-ray regions, however, the emission comes more and more from hot spots on the sun. This is known from the photograph of the sun obtained with the Lyman-alpha line of hydrogen, by Purcell, Packer, and Tousey[1], and from the solar photograph made with 20–60 Å X-rays by Blake, Unzicker, and Friedman.[2]

For environmental calculations, however, the radiation from the entire solar disc is the quantity to be considered. The irregular nature of the emitting surface is of interest principally because it reflects the fact that the emission from the sun changes from time to time, as the sun's rotation brings new regions into view, and as the activity changes during the sunspot cycle.

The spectral intensity distribution of sunlight outside the earth's atmosphere is known with high resolution and reasonably (CONTINUED ON PAGE 52)

COSPAR again—bread and salt

Florence meeting provides food for thought about the international impact of major space events and growth of astronautics worldwide

By R. B. Rypinski

SPACE TECHNOLOGY LABORATORIES INC., LOS ANGELES, CALIF.

FLORENCE, ITALY—The 2nd International Space Science Symposium of the Committee on Space Research (COSPAR) took place at the Pitti Palace, Florence, Italy, from April 10–14 this spring.

For your correspondent, the high spots of this meeting were the all-day session of national and union reports on the first day and the extracurricular session on the evening of the last day, Thursday. This latter event saw the mayor of Florence and a vast audience of his compatriots give a wild reception for A. Blagonravov and A. G. Masevich of the USSR delegation.

In the conference proper, it was impressive to see and hear delegates from all of the countries which reported get up, one by one, and confirm the truly international nature and impact of the space age so far. It is difficult to believe that Sputnik I was orbited only $3^1/_2$ years ago, and then to consider the implications of the next few years in the light of the obvious tidal wave of interest and activity in space matters among scientists of the world.

In this particular conference, with its emphasis on scientific investigation and achievement, it would appear that the U.S. came off with fairly obvious first honors except for the nagging, underlying consciousness of the quantitative superiority of Russian space loads. This was emphasized by the announcement of their man in space on April 12.

The presentation of national reports in alphabetical order resulted in a dramatic conclusion with the reports of the UK, the USA, and the USSR. Professor H. S. W. Massey of the UK, in a well-organized discussion, presented what appeared to be a well-controlled and planned program with perhaps the highest ratio of gain for effort. Richard Porter touched lightly on the U.S. scientific programs including Project Mercury, and concluded with a renewal of America's March 1959 offer of cooperation and an appeal for further takers in this cooperative effort. The Russian report, read by an interpreter who obviously knew English, but just as obviously did not know space science, seemed a rather impersonal statistical catalog of Soviet triumphs.

Details of U.K., U.S., and USSR Reports

Interesting UK program information included (1) the active and growing interest by the British Meteorological Office in rocket matters, and their expressed intent to take over all meteorologic space work from the scientists who have been doing it so far; (2) because of UK weather limitation, an optical station is being established in Malta; (3) space study by sounding rocket including the ionosphere, in which the dominance of NO^+ ions has been confirmed by three groups, although propagation studies of all frequencies are being carried forth; (4) British satellites for Scout launchings, cosmic radiation will be monitored but there are no plans to study Van Allen belts; (5) from both vertical soundings and satellites, X ray and Lyman alpha (at 1700 Å) will be studied, especially by rocketsondes at Woomera; and (6) using stabilized platforms, sondes will study ultraviolet radiation.

Dr. Porter of the U.S. emphasized (1) utility and desirability of balloons, (2) height and weight characteristics of Nike Cajun, Aerobee Hi, Javelin, and Journeyman probes, and (3) the performance of the Pioneer V. Discussing future plans, he said that 1961 would see approximately 150 balloons and 120 vertical sounding rockets launched, no launching of either active or passive communications satellites, but the distribution in a polar orbit of a belt of tiny dipoles for com- (CONTINUED ON PAGE 97)

Aerospace probing over the Gulf

The well-instrumented arena of the Gulf of Mexico sees increasing use for space research and missile development programs

By Martin P. Brown

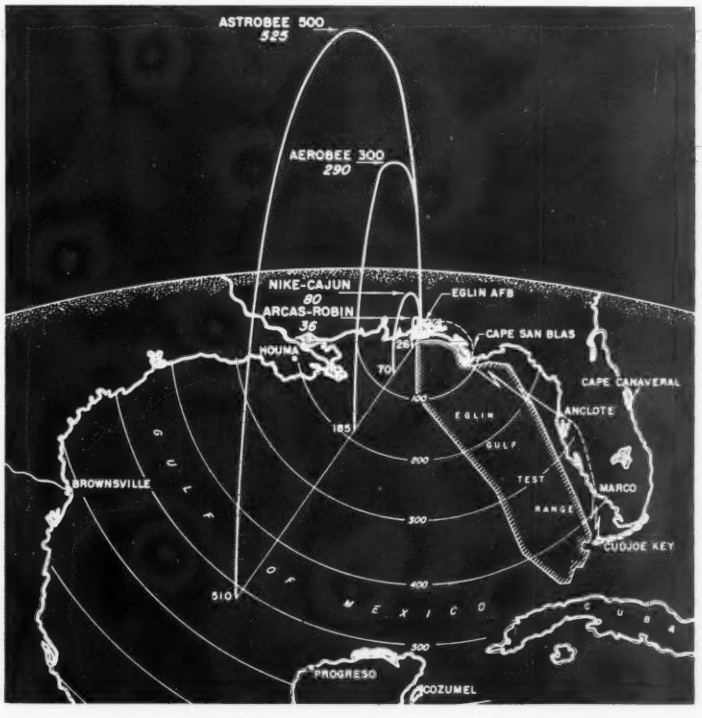
EGLIN AIR FORCE BASE, FLA.

THE PRESSING need to obtain data for military research programs, to test weapon components, and to assist in securing scientific data for use in the peaceful exploration of space is accelerating the use of economical vertical probes over the Gulf of Mexico.

The Air Proving Ground Center at Eglin Air Force Base, located on the Gulf coast about half-way between Pensacola and Panama City, began its vertical-probe launch program in March 1959 and has launched approximately 100 vertical probes to date. These launchings were mainly in support of AFBMD, AFRD, and WADD of the Air Force Systems Command. A total of 135 launchings are already scheduled for this year.

The space above the Gulf of Mexico impact area, together with Eglin's advanced instrumentation capability, provides a vast arena for the conduct of both simple and sophisticated test programs.

Typical Probes over the Gulf



Martin P. Brown is technical director of the Aerospace Directorate at Eglin AFB. After receiving an Engineer of Mines degree from the Colorado School of Mines, he served throughout World War II in the Corps of Engineers. His experience with rockets and test-range activity began in 1947 at the Naval Ordnance Test Station, China Lake, Calif., and continued there until 1954 when he transferred to Eglin as head of its Advance Planning Branch, which initiated extensive test-range improvements at Eglin and along the Florida coast. Brown is a registered professional engineer in Florida, California, and Washington, and is a member of the Florida Engineering Society and the National Society of Professional Engineers, as well as ARS.

In the Firefly program, a Nike-Cajun launches just before dawn to create an artificial ionized cloud at high altitude.

The configuration of the Gulf shore from Key West, Fla., northward has been utilized for the strategic location of instrumentation to obtain time-space-position data and telemetry reception. The almost circular perimeter of the Gulf provides optimum geometrical conditions for instrumentation placement to obtain accurate data from events occurring in aerospace over the Gulf.

Test vehicles and payloads are assembled, checked-out, and launched from the Aerospace Facility on Santa Rosa Island, which is approximately 15 mi from Eglin's main base. Four launchers located along a line 100 yd from the shore can be orientated to utilize a large portion of the Gulf of Mexico as an impact area.

Launch Facilities

The Aerospace Facility consists of test-vehicle assembly, preparation, and checkout areas, a solid-propellant-vehicle launch complex, and a liquid-propellant-vehicle launch complex.

The solid-propellant-vehicle launch complex consists of a control building, two Jason launchers for vehicles weighing up to 10,000 lb and a Cree-type launcher capable of accommodating vehicles weighing up to 40,000 lb. The Jason launchers can be elevated to 90 deg and the Cree to 87 deg. Both launchers can be oriented in azimuth over a 90-deg arc.

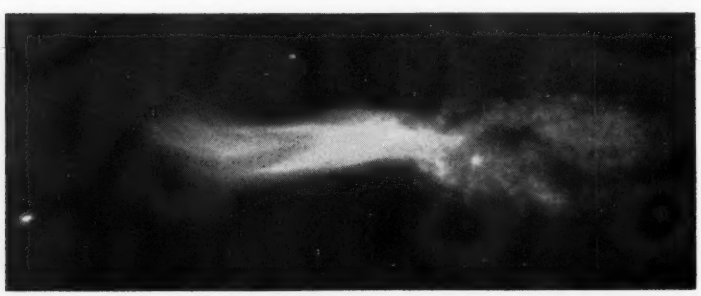
The liquid-propellant-vehicle complex consists of a 162-ft Aerobee-type launcher capable of 90 deg of traverse in azimuth and adjustment of 10 deg from the vertical. This launcher can accommodate motors up to 22 in. in diam with a fin envelope of 120 in. This complex also includes liquid-propellant storage and handling equipment, a helium pressurization system (5000 psi), and a launch-control building.

Vertical-Probe Types

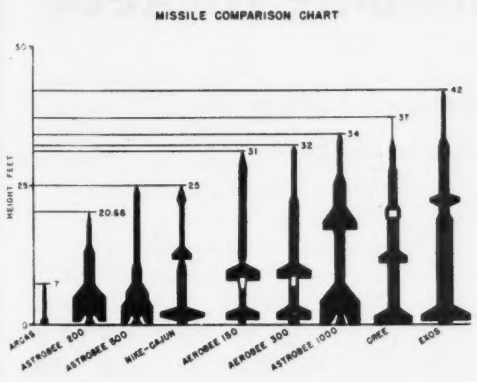
The present launch schedule includes test vehicles ranging in performance from the 7-ft Arcas to the 25-ft Astrobee 500. Test vehicles of much higher performance are under consideration.

The selection of a vehicle for a particular test depends primarily on the payload weight and configuration and the altitude required. Other significant factors include the maximum acceleration acceptable, time available for vehicle procurement, and the number of vehicles required for a particular program, and cost.

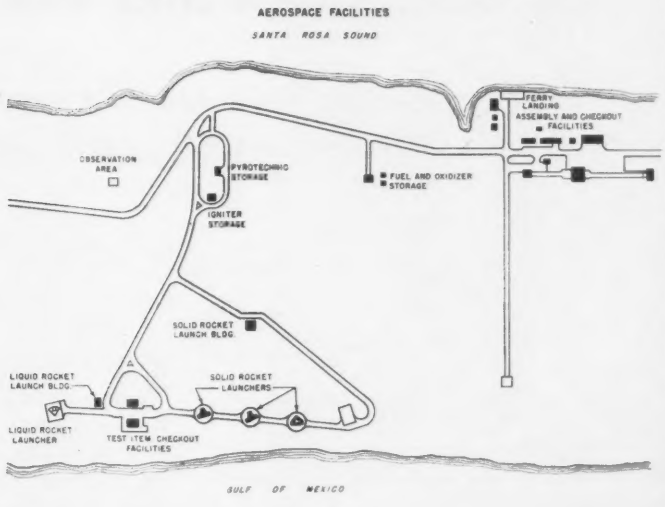
Attitude stabilization of the payload after release from the test vehicle and recovery of the test item from the water will be required in certain anticipated test programs.



Test Vehicles for Probe Programs



Aerospace Facilities at Santa Rosa Island



Multiple launchings, launchings coordinated with test activities at other ranges, re-entry simulation by means of retrofiring into the atmosphere from the test vehicle, and programmed test-vehicle maneuvers are techniques that are under consideration for advanced testing.

Experience has proved that extensive testing of components in the aerospace environment is essential in achieving operational reliability. This reliability can be developed and insured by a program of inexpensive probe testing of the type now being performed before components are installed in a million-dollar vehicle or satellite.

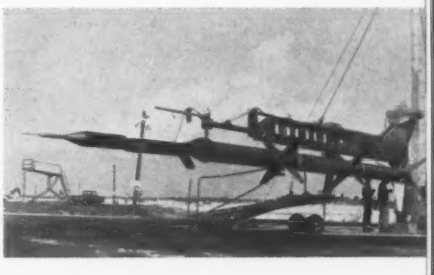
Indicative of the low cost of probe-test programs is the cost per pound per mile of altitude in present types of test vehicles—$0.70 to $2.25.

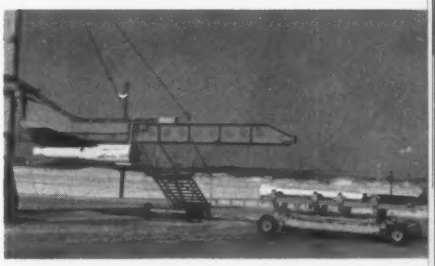
These test programs can use to good advantage many of the weapon boosters that are becoming surplus, as they near the end of shelf life or are replaced with improved types. Use of these surplus boosters in combination with some of the excellent motors now available from a number of sources insures a ready supply of economical test vehicles.

Vertical-Probe Programs

A variety of objectives exist in the over-all launching program. Generally, programs have been conducted or are scheduled to obtain data for space research projects and to test weapon components under development. Some of the programs are the following.

The Arcas-Robin program is being conducted to develop a technique for obtaining meteorological data at altitudes from 100,000 to 250,000 ft. The test vehicle is an Arcas solid-propellant rocket which propels a payload containing a deflated plastic balloon with a collapsible radar corner reflector. Made (CONTINUED ON PAGE 66)





Top to bottom, Cree, Astrobee-500, and Arcas-Robin test vehicles being prepared for launch.

Sandia's D-A and V-A sounding rockets

Based on reliable off-the-shelf solid motors, these two rockets provide an economical means for simple small-budget experiments

By Charles T. Force

SANDIA CORPORATION, ALBUQUERQUE, N.M.

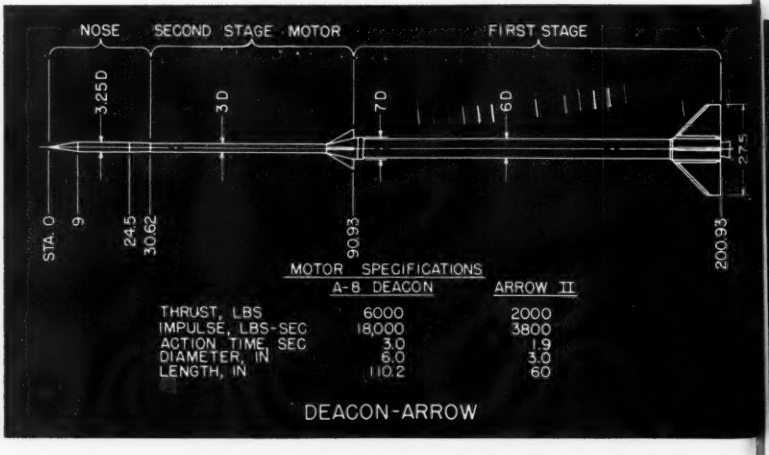
SANDIA CORPORATION has recently developed two small, low-cost sounding rocket systems. The basic design requirement was that the rockets be capable of carrying nose cones weighing 15 to 20 lb to an altitude of approximately 100 mi. As illustrated below, the 17-ft-long, two-stage rocket systems are characterized by 6-in.-diam, solid-propellant first stages topped by 3-in.-diam, solid-propellant second stages. Propulsion units which are employed include Allegany Ballistics Laboratory's Deacon and Grand Central Rocket's Viper in the first stage and Grand Central's Arrow in the second stage—hence the names D-A (Deacon-Arrow) and V-A (Viper-Arrow).

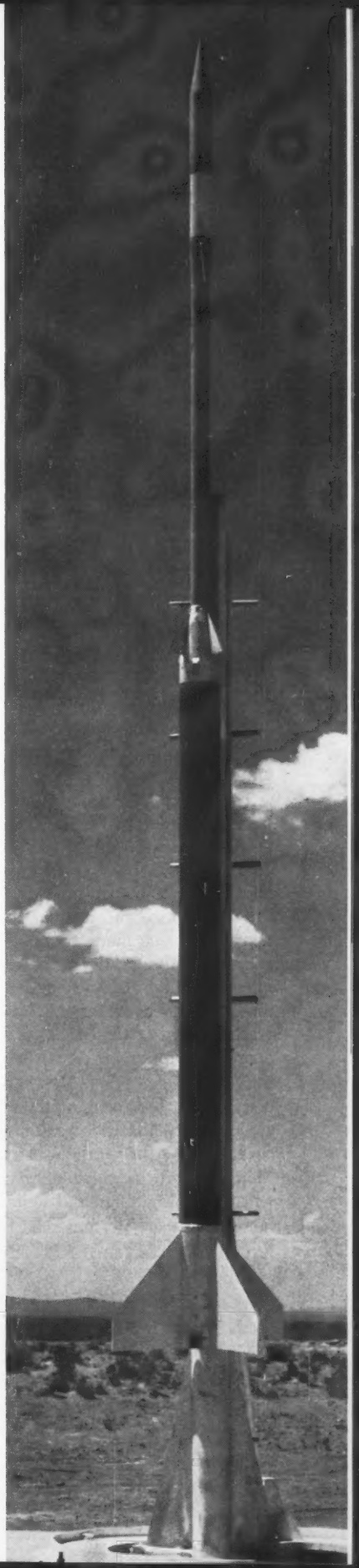
In an 18-month period following the initiation of the project, Sandia flew more than 125 D-A rockets and 12 V-A rockets. Discounting the developmental program, the reliability attained by the D-A system was 96%. Operationally the system is very simple: Field assembly and loading on the launcher require three men, approximately 2 man-hours, and no auxiliary power equipment.

Simplicity was stressed in the design of the systems. The first stage consists of fin assembly, propulsion unit, and a novel interstage adapter. The second stage, which is interchangeable between boosters, consists of fin assembly, propulsion unit, nose adapter, and nose. The Sandia-designed noses have been of two basic types—

Charles T. Force, a staff member in the Aerodynamics Research Div. of Sandia Corp., was the project engineer on the Deacon-Arrow and Viper-Arrow programs. Since receiving a B.S. in aeronautical engineering from Purdue Univ. in 1957, he has been engaged in design and development of high-altitude research rockets at Sandia.

Design Sketch of Deacon-Arrow





Viper-Arrow ready for flight.

one carrying chaff and the other telemetry. The chaff rocket dispenses its load at altitudes of interest. Groundbased radars then track the chaff to determine the horizontal wind-velocity vector. Most of the telemetry packages have utilized the Bendix TXV-13 transmitter with up to five subcarrier oscillators to obtain five separate channels of information.

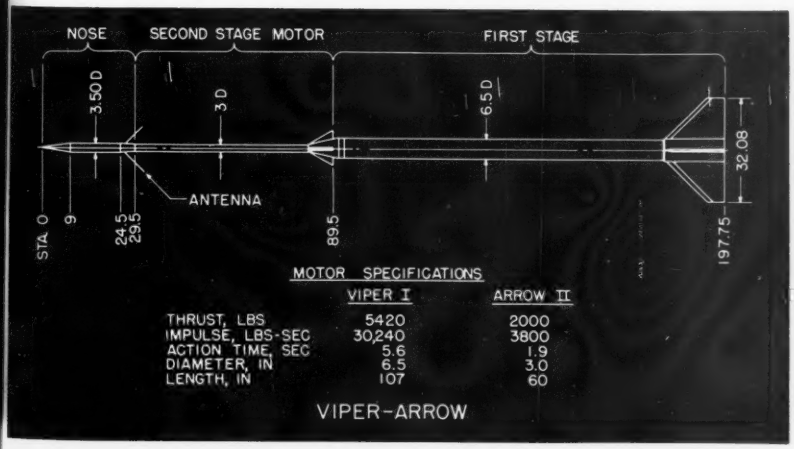
The developmental program was such a crash project that less than two months elapsed between its inception and the first successful flight test. Consequently, the selection of propulsion units was governed by availability. Of the rocket motors immediately available, only the combination of a Deacon and an Arrow had the necessary capability. As it turned out, these motors can be combined into a very satisfactory rocket system. The propulsion units have proved reliable and are aerodynamically and mechanically compatible. The Viper-Arrow, which evolved later in the program, when an increased altitude capability was desired, is not as thoroughly developed as the Deacon-Arrow.

Aerodynamic Adaptations

Cruciform fins are used on both stages. A 45-deg clipped-tip delta planiform was chosen for the first stage, while a 60-deg delta planiform was selected for the second stage. The fins had to be placed in line, rather than interdigitated 45 deg, because of launcher interference. The exposed fin area of the second stage, although in the interstage adapter, is small, and the effect of the wake on the first-stage fins is negligible. A roll is introduced to reduce the dispersion caused by factors such as a trim angle or a misaligned thrust vector; the vehicle is caused to roll by canting the fins relative to the longitudinal vehicle axis.

The interstage-adapter design is such that the second stage may be rapidly centered and securely tightened (CONTINUED ON PAGE 60)

Design Sketch of Viper-Arrow



ARS Senior Member grade established

New grade of Benefactor also set up . . . Qualifications for all membership grades changed . . . Reinstatement fee of $5 instituted

By Geoffrey Potter

ARS MEMBERSHIP MANAGER

A NEW MEMBERSHIP grade, Senior Member, has been established by the Board of Directors of the American Rocket Society, effective July 1, 1961. The new grade has been initiated to recognize significant performance and distinction by engineers and scientists in the rocket and space field.

In announcing the revision of ARS membership grades, the Board of Directors also disclosed a new grade of Benefactor.

The lineup of ARS membership grades will be: Benefactor, Fellow Member, Senior Member, Member, Associate Member, and Student Member. A complete description of all membership grades and the qualifications for each grade will be found on the facing page. In general, membership qualifications have been made more stringent in each category, and although three references are still required for each grade, it is now necessary that two of the three references be by ARS members of the same grade or higher than that for which the proposed member is applying.

The fees for Student Member will remain at $5.00 per year for those wishing to receive only one magazine and $9.50 for those wishing to have both *Astronautics* and *ARS Journal*. Associate Members and Members will continue to pay $15.00 per year as will Senior Members and Fellow Members. Benefactors, who are persons who have contributed not less than $10,000 to the Society, will be given life memberships.

Inasmuch as the new qualifications for Fellow Membership indicate that candidates must have been Senior Members for five years, the ARS Board has decided that, rather than declare a moratorium on the election of Fellow Members during the next five years, candidates will be persons who would have been eligible for Senior membership for at least five years. This exception will not be made until 1962.

The Board also announced the establishment of a membership reinstatement fee. Henceforth, a charge of $5.00 will be made for those wishing to reinstate their memberships after four months beyond the billing date, when their stencils are removed from the mailing list and their roster cards are taken from the files, up to two years after the billing date.

Forms for Senior Memberships Mailed Out

The Board of Directors stated that a special committee has selected several hundred distinguished ARS members, whose backgrounds and performance have been carefully reviewed, as the first ARS Senior Members. A mailing is to be made to all other ARS members explaining the new grade structure and enclosing an application form for all those who wish to apply for Senior Membership. A list of the original Senior Members will be enclosed to announce their appointment and to be used as a reference.

Henceforth, separate application forms will be used for all ARS grades for which application can be made. Abe Zarem, chairman of the ARS Membership Committee, urges all Sections and Student Chapters to make sure an adequate supply of all of the forms is on hand and that member applicants are instructed to use the proper forms when applying for ARS membership. Inquiries regarding membership should be addressed to Geoffrey Potter at the American Rocket Society, 500 Fifth Avenue, New York 36, N. Y.

MEMBERSHIP GRADES

in the

American Rocket Society

MEMBERSHIP

All persons professionally engaged in science or engineering relating to rocketry and astronautics are eligible for membership and will be assigned grades commensurate with educational attainment and with professional experience. Applications for admission to, or transfer from, one grade to another will be reviewed by the Membership Committee or its authorized representatives.

Persons holding Bachelor's degrees in science or engineering from accredited universities, colleges or technological institutes after four or more years of study, are deemed to have four years of professional experience.

MEMBERSHIP GRADES

Benefactors

Shall be persons approved by the Board of Directors who have contributed not less than $10,000.00 to the Society. Benefactors shall enjoy life membership.

Fellow Members

Shall be professional persons who have made valuable and important engineering or scientific contributions in or related to rocketry and astronautics and attained national distinction in their fields. They must have made original contributions of exceptional merit or have been in responsible charge of important scientific or engineering programs. They must have been Senior Members for five years. Fellow Members are proposed by the ARS Awards Committee and elected by the Fellow Members of the Society. Voting is by secret ballot and a favorable vote of three-fourths of those voting is required for election. The number of Fellow Members elected each year shall not exceed 1/10th of 1% of the total membership of the Society.

Senior Members

Shall be professional persons of at least ten years experience in science or engineering in or related to rocketry and astronautics who have, by above average performance in at least four of those years, attained distinction in their fields. Such performance is defined as one or more of the following: 1) publication of important original scientific papers, books or inventions; 2) contribution to the welfare of scientific or engineering professions; 3) accomplishment of important scientific or engineering work; 4) direction of important engineering or scientific projects. The Senior Member grade is the highest grade of membership for which application may be made. Applicants must be recommended by three persons, two of whom must be Senior or Fellow Members.

Members

Shall be professional persons with at least six years experience in science or engineering in or related to rocketry and astronautics who have demonstrated competence in their fields. Applicants must be recommended by three persons, two of whom must be of the Member grade or higher.

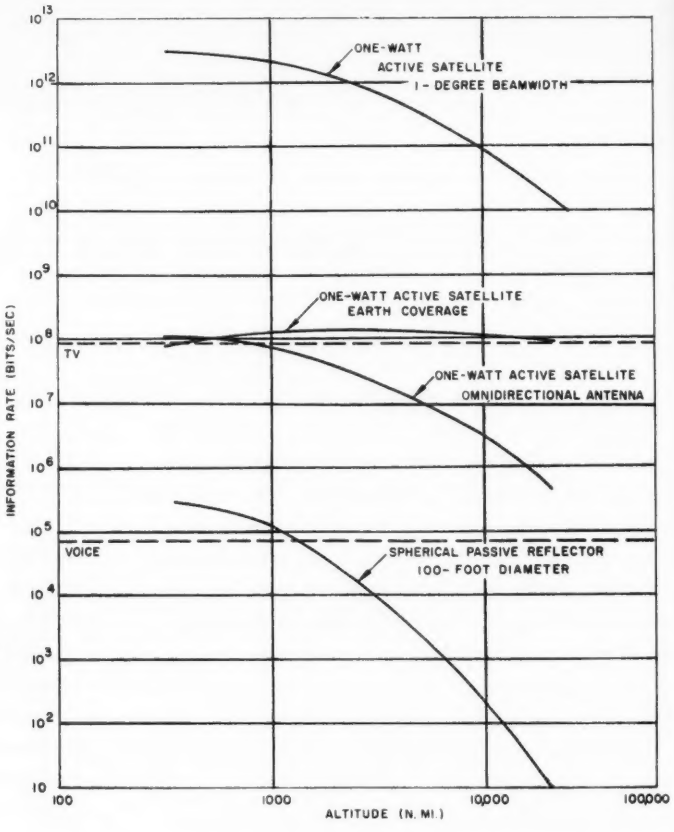
Associate Members

Shall be persons having professional activity or interest in fields in or related to rocketry and astronautics. Applicants must be recommended by three persons, two of whom must be of Associate Member grade or higher, except that Student Members, upon completion of their education, are automatically eligible for Associate Member grade without additional recommendations.

Student Members

Shall be undergraduate or graduate students, under 28 years of age, who are in full time attendance at accredited universities, colleges, or technological institutes.

Information Rate Vs. Altitude For Communication Satellites



Communication satellites—how high?

Active-repeater satellites in 12-hr polar or 24-hr equatorial orbits, it is argued, give best performance with the least cost . . . The effect of signal delay on the user will decide which of these two is commercially practical

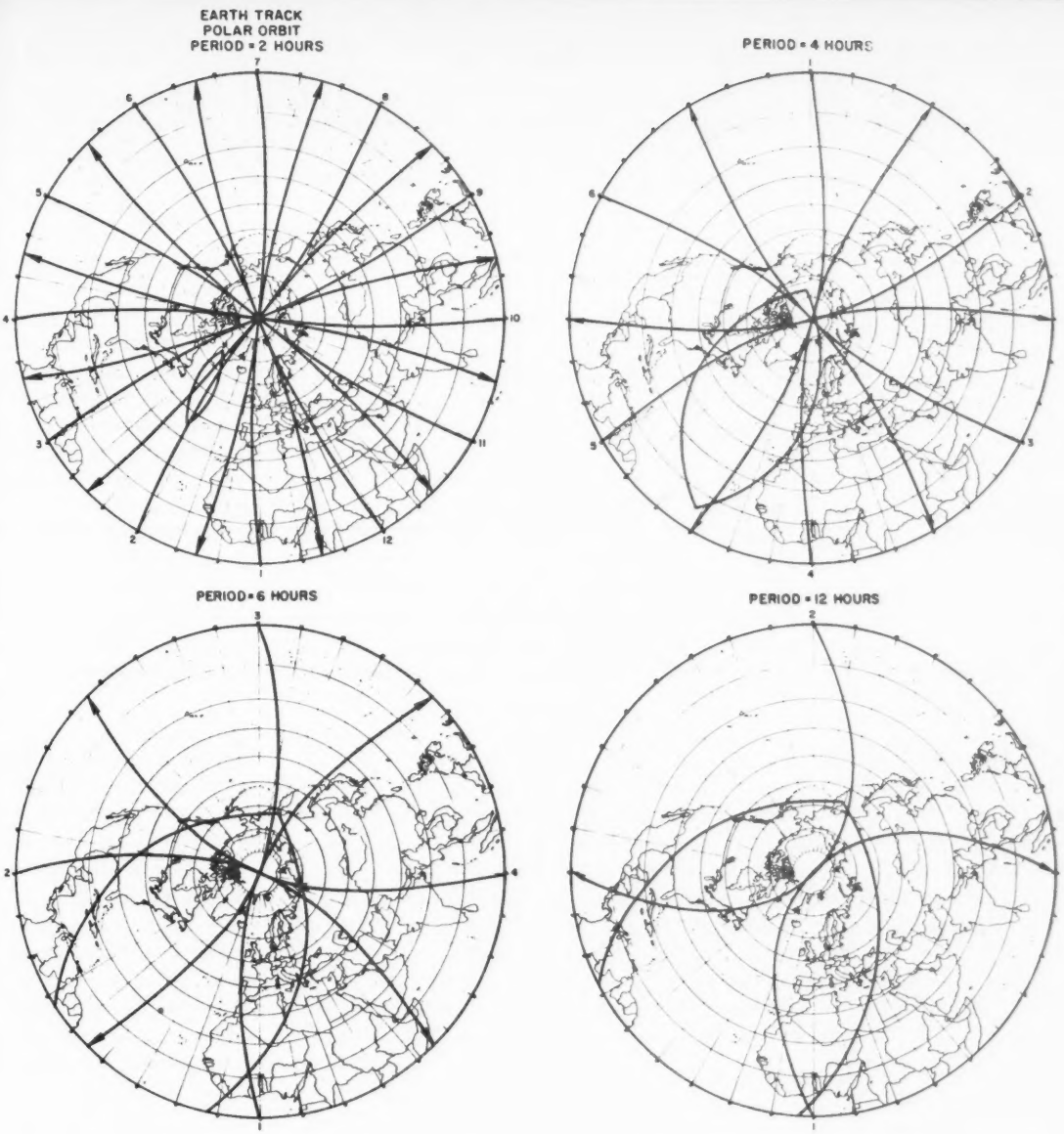
By G. E. Mueller, W. B. Hebenstreit, and E. R. Spangler

SPACE TECHNOLOGY LABORATORIES INC., LOS ANGELES, CALIF.

EXAMINATION of the many problems bearing on the establishment of a communications relay system using earth satellites has led to a general agreement among investigators that such a system is now technically feasible and that it can be economically profitable. There is still considerable discussion, however, concerning many of the specific system choices which must go into the design of the satellite. Here we plan to discuss one of these choices, leading to the conclusion that active relays in circular orbits with periods of 12 or 24 hr appear to be optimum for a communications satellite system.

As an introduction, let us look at one of the basic system parameters which depends on altitude of the satellite—the information rate. The type of service establishes minimum information rates; that is, a single voice channel requires a rate of transmission of information of about 10^5 bits per sec, while a television picture requires about 10^8 bits per sec.

The graph on this page summarizes the information that can be transmitted by passive and active repeaters for a typical set of system constraints. It is apparent that it is not practical to transmit a voice channel by means of a passive reflector at any altitude higher than about 2000 mi., and even at this altitude it would probably not be possible to achieve the minimum signal-to-noise requirements for toll-line communications. The active repeater with om-



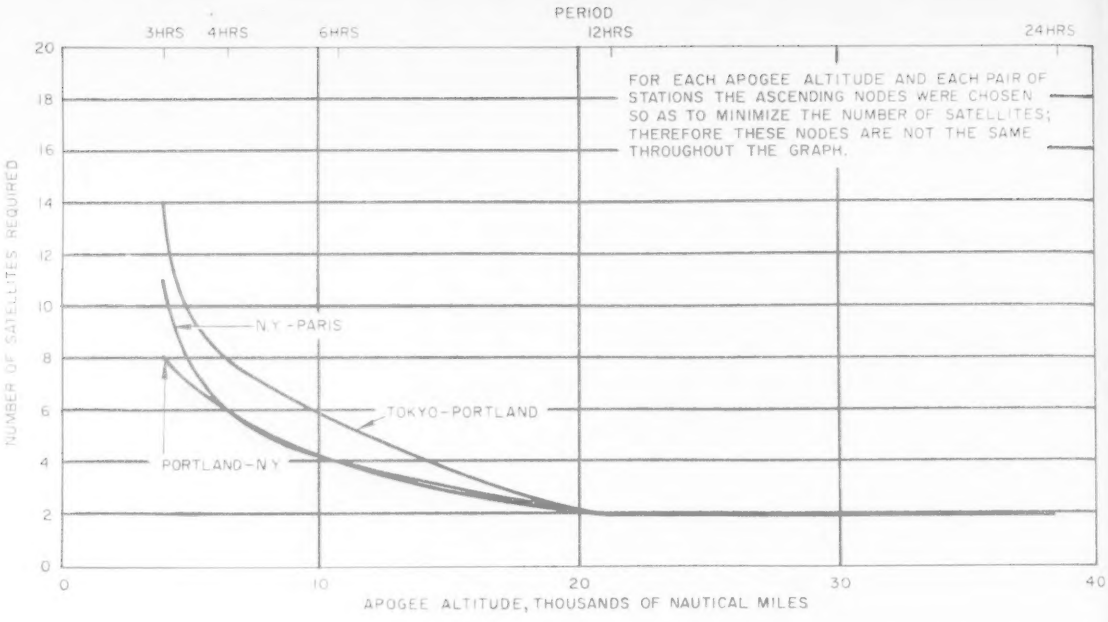
Suborbital paths for polar satellites in circular orbits at various altitudes, showing mutual visibility between New York and Paris.

nidirectional antennas is similarly limited by path loss to altitudes less than 4000 mi. for toll-quality television. The clear necessity for directional antennas for wideband toll communications in high-altitude satellites is shown by the curves for directional antennas.

Advantages of Active Repeaters

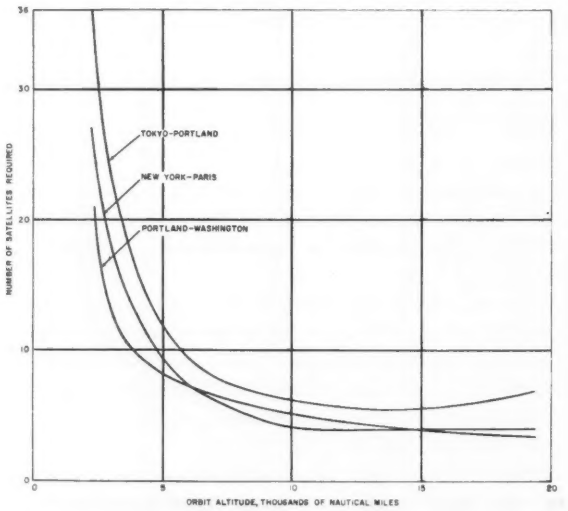
We conclude that the relatively low information capability possible with passive satellites and the large number of these reflectors which would be needed leads to the choice of active repeaters for commercial communications and for normal military communication. Moreover, as will be shown later, the use of active repeaters permits a significant cost saving in the creation of a satellite communication system.

There is less unanimity today concerning the selection of an orbit than such factors as operating frequency and bandwidth. This is not surprising; selection of orbits is interwoven with many other system elements and parameters in a relatively complex fashion. There are, of course, an infinite number of possible, and perhaps even feasible, orbital sets. We shall endeavor to develop some criteria by which we can narrow the field to one or, at most, a favored few.


PERIOD
3HRS
4HRS
6HRS
12HRS
24HRS
FOR EACH APOGEE ALTITUDE AND EACH PAIR OF STATIONS THE ASCENDING NODES WERE CHOSEN SO AS TO MINIMIZE THE NUMBER OF SATELLITES; THEREFORE THESE NODES ARE NOT THE SAME THROUGHOUT THE GRAPH.
NUMBER OF SATELLITES REQUIRED
N.Y.-PARIS
TOKYO-PORTLAND
PORTLAND-N.Y.
APOGEE ALTITUDE, THOUSANDS OF NAUTICAL MILES

Satellites needed in inclined elliptical orbit for continuous communications between three pairs of cities.

Each satellite will be visible on the earth at any point within a circle whose center is directly beneath the satellite and whose diameter increases with increasing satellite altitude. As one approaches the perimeter of this circle, however, a greater amount of the earth's atmosphere must be traversed to reach the satellite, a fact which leads, at very low elevation angles, to a frequency-dependent attenuation. This effect decreases rapidly as the elevation of the source increases above the horizon, and, in fact, can usually be neglected for elevation angles of 10 deg or more. In addition, a ground antenna aiming far enough down toward the horizon to include a portion of the surface of the earth in its main beam will have an effective noise temperature between that of space and that of the earth. Thus, for satisfactory communications the satellite must always be at least a few degrees above the horizon at the point on the earth seeking to use the satellite. This minimum elevation, δ, can be between 5 and 10 deg, depending on the quality of transmission desired and the type of communication equipment used. In all calculations throughout this paper, a δ of 7.5 deg has been assumed.



Satellites needed in circular polar orbits for continuous communications between three pairs of cities.

The radius of the coverage circle in degrees is the angle, δ, subtended at the center of the earth, given by $\theta = [\cos^{-1}(R/R + h\cos\delta)] - \delta$ where R is the radius of the earth and h is the altitude of the satellite. The increase in coverage permitted by increasing satellite altitude is quite significant at altitudes below 5000 mi., but above this altitude the increase in coverage with altitude becomes less pronounced. If we take two sites on the globe between which we wish to maintain communications, such as New York and Paris, and a satellite in a circular polar orbit passing between these two cities, a 2-hr orbit (1040-mi. altitude) with a θ of 30 deg (and a coverage circle on the earth, therefore, with a diameter of 60 deg) will permit a maximum joint visibility of about 10 min per orbit. Raising the satellite to a 4-hr orbit (3962 mi.) increases this period of mutual visibility for these orbits. The earth tracks traced by the suborbital points of the orbits are shown on page 43.

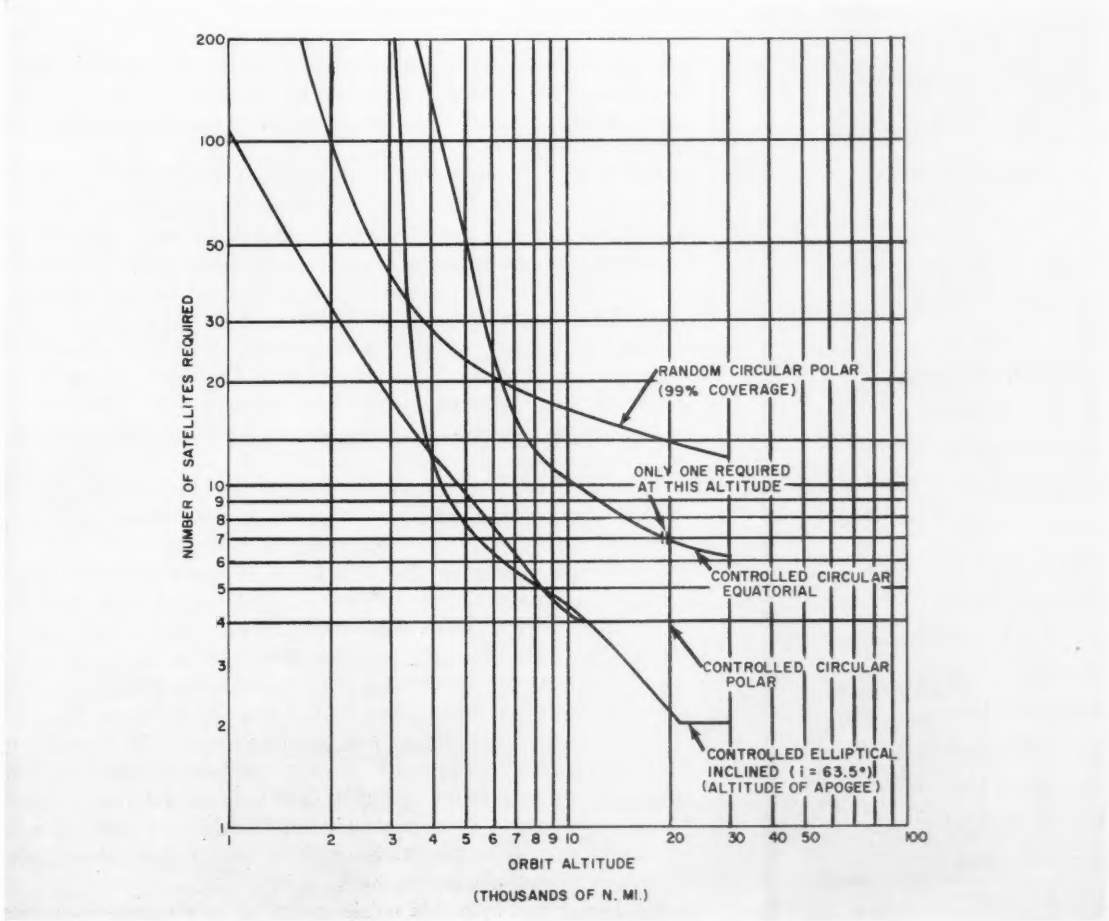
Thus, one satellite in polar orbit will provide a communications link between New York and Paris for a percentage of time which will increase with altitude. Coverage, of course, will also vary with the position of the plane of the orbit with respect to the two cities. As can be deduced from the charts on page 43, at low altitudes the satellite orbit will frequently provide no mutual visibility.

If two sites are selected at opposite sides of the equator—say Miami and Buenos Aires—then the polar orbits are no longer optimum. A satellite in an equatorial orbit will provide more frequent periods of mutual visibility in these cases, assuming it is above the minimum altitude which provides any mutual visibility at all. In addition, since a satellite in orbit directly over the equator will trace out the same earth track on every orbit, the problem of useless orbits does not arise.

Circular orbits are in many ways the most attractive for providing uniform coverage over the earth and a uniform signal-to-noise ratio. However, there are advantages in elliptical orbits, particularly those inclined at 63.5 deg, which with the proper choice of period permits a stationary earth track. The elliptical orbit has the advantage that, with a given booster strength, a greater satellite weight can be placed at the apogee of an elliptical orbit than at the altitude of a circular orbit, when these heights are equal. If the orbit is planned so that apogee occurs during the day in mutual view of densely populated areas and perigee during the night over ocean or desert, an efficient use of the satellite can be obtained.

Fewer Satellites Needed

It is possible with a limited number of satellites in elliptical orbits to provide coverage for the daylight hours between most of the communication centers of the world. The graph on page 44 shows the number of satellites in inclined elliptical orbit needed for continuous communication coverage between three pairs of cities (CONTINUED ON PAGE 82)



Satellites needed for continuous coverage between New York and Paris.

Program jelling for XIIth IAF Congress

Marriott Hotel in Washington selected as site of meeting Oct. 2-7 . . . Attendance of 1000 anticipated . . . Academy of Astronautics, Institute of Space Law to meet . . . Tour of NASA Goddard Space Flight Center set

By James J. Harford

EXECUTIVE SECRETARY, AMERICAN ROCKET SOCIETY

XIIth International Astronautical Congress Committee

Samuel Herrick
Chairman

George R. Arthur
George D. Colchagoff
Hugh L. Dryden
Donald D. Flickinger
Herbert Friedman
Arnold Frutkin
George Gerard
John P. Hagen
Andrew G. Haley
George J. Kidera
David B. Langmuir
Chauncey D. Leake
Alfred M. Mayo
Knox Millsaps
William H. Pickering
Harold W. Ritchey
Howard S. Seifert
John L. Sloop
Theodore von Karman

THE MARRIOTT Twin Bridges Hotel in Washington, D. C., has been selected as the site for the XIIth International Astronautical Congress, to be held October 2–7, with the American Rocket Society, in cooperation with the American Astronautical Society and the Aero-Space Medical Assn., as host society.

Samuel Herrick, chairman of the XIIth IAF Congress Committee, announced last month that the Marriott had been selected not only because of its size, excellent meeting facilities, comfortable sleeping rooms, and reasonably-priced restaurant, but most of all to give foreign visitors the experience of attending a meeting in a characteristic American environment.

The hotel is located near Washington's International Airport, across the Potomac River from Washington's downtown area, just a 15- to 25-min ride away from the center of the city. Shuttle bus service is planned throughout the week of the meeting to facilitate travel to and from other Congress hotels and downtown Washington.

All of the Technical Sessions, the International Academy of Astronautics and Institute of Space Law meetings, and the banquet will be held at the Marriott. The site of the IAF Plenary Sessions has not as yet been selected. The receptions and other social events will be held in downtown Washington, with transportation provided to these locations.

Because of the large number of rooms the Marriott was able to offer for the meeting, ARS has cancelled its commitment for space at the Sheraton Park, the Mayflower, and the Statler-Hilton Hotels.

Dr. Herrick also announced that plans for the technical program are now firming up, and the full program is expected to be available in the near future. The tentative technical program is shown on the facing page. The Annual Banquet will be held on Thursday evening, October 5. A tour of NASA's Goddard Space Flight Center is also planned during the meeting, as well as a trip to Mount Vernon.

A full Ladies Program has been organized under the direction of Betulia Herrick. While plans have not as yet been finalized, the program will include tours of public buildings of interest, schools, homes, and housing developments in the Washington area. Events of special interest to the ladies, such as teas, fashion shows, and luncheons, are also being planned.

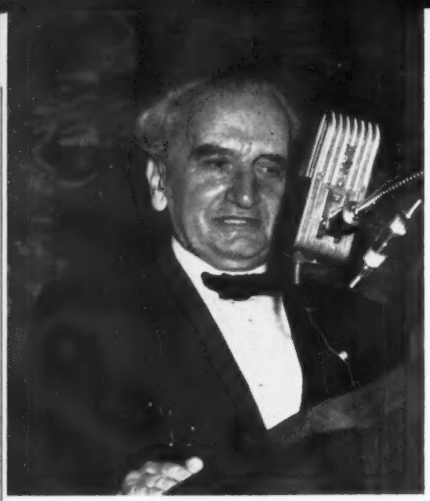
The Congress Committee requests that all IAF member societies submit the names of those scientists and engineers in their own

countries who they feel are particularly well qualified to participate in the scheduled roundtable discussions at the Congress directly to Dr. Herrick. Suggestions should be mailed to: Prof. Samuel Herrick, Chairman, XIIth International Astronautical Congress, Univ. of California, Los Angeles 24, Calif., U.S.A.

Additional information concerning the Congress is available from ARS Headquarters. Queries should be addressed to Rod Hohl, Meetings Manager, American Rocket Society, 500 Fifth Avenue, New York 36, N.Y., U.S.A. ♦♦

Tentative Technical Program, XIIth IAF Congress

Date	Time	Session	Chairman
Tuesday, Oct. 3	MORNING	Space Propulsion	Frank Rom
		Astrodynamics and Guidance Roundtable	Robert M. L. Baker Jr.
		Academy of Astronautics	Theodore von Karman
		Institute of Space Law	Andrew G. Haley
	AFTERNOON	Energy Conversion	Abe M. Zarem
		Structures Roundtable	Max L. Williams
		Institute of Space Law	Andrew G. Haley
Wednesday, Oct. 4	MORNING	Combustion	Peter L. Nichols Jr.
		Space Physics Roundtable	Herbert Friedman
		Institute of Space Law	Andrew G. Haley
	AFTERNOON	Space Medicine Roundtable	Brig. Gen. Don Flickinger
		Astrodynamics and Guidance	Robert M. L. Baker Jr.
		Institute of Space Law	Andrew G. Haley
Friday, Oct. 6	MORNING	Space Communications Roundtable	Eberhardt Rechtin
		Vehicles	Max L. Williams
	AFTERNOON	Instrumentation Roundtable	Henry L. Richter Jr.
		Bio-Astronautics	Brig. Gen. Don Flickinger
		Space Physics	Herbert Friedman



Von Karman at 80

700 honor aviation-space pioneer at day-long birthday celebration in Washington . . . Annual Von Karman Lecture established by ARS

By Irwin Hersey

AVIATION-SPACE pioneer Theodore von Karman, an inspiration to two generations of aeronautical and astronautical scientists and engineers, was guest of honor at a day-long 80th birthday celebration in Washington, D.C., on May 12. The birthday party was another in a life-long series of red-letter days enjoyed by the most respected scientist in his field, getting underway with a symposium sponsored by the Air Force Office of Scientific Research and closing with a banquet drawing an attendance of about 700 at which more than 50 different organizations paid tribute to a man described by banquet speaker Joseph V. Charyk, Undersecretary of the Air Force, a former von Karman student, as a rare combination of genius, leader, counselor, and man of vision.

The all-day program got underway with a lecture session opened by Knox Millsaps, AFOSR executive director, and chaired by Hugh L. Dryden, NASA deputy administrator. The four invited lecturers covered areas in which von Karman has made significant contributions.

The opening lecture at the morning session, delivered by Nicholas J. Hoff, head of the Aeronautical Engineering Dept. at Stanford Univ., was devoted to "Buckling of Thin Shells," while the second lecture of the morning was on the subject of "The Karman Vortex Street in Magnetofluiddynamics" and was given by Adolf Busemann, NASA Langley Research Center staff scientist.

Lectures at the afternoon session, chaired by William R. Sears, director of the Graduate School of Aeronautical Engineering at Cornell Univ., were delivered by Joseph Kaplan, physics professor at the Univ. of California at Los Angeles and vice-president of the International Union of Geodesy and Geophysics, who spoke on "International Cooperation in Science," and by Martin Summerfield, professor of aeronautical engineering at Princeton Univ., ARS Board member and Editor of *ARS Journal*, who spoke on "Flame Propagation Phenomena in Solid Rocket Propellants," with particular attention to ignition problems.

Von Karman contributed a series of pithy comments on each of the papers in his inimitable fashion.

Banquet a Stellar Event

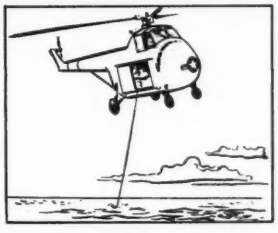
The banquet that evening was a stellar event even by Washington standards, turning out most of the leading figures in the worlds of aviation and space technology, many of them one-time students of the Master. Toastmaster at the banquet was a fellow Hungarian, Edward Teller, director of the Univ. of California Radiation Laboratory. Highlights of the evening included the address by Dr. Charyk, the impressive tributes to von Karman delivered by some 50 cooperating organizations, and the opening and closing remarks by von Karman himself.

ARS, which was one of the cooperating organizations, was represented by William H. Pickering, ARS National vice-president and director of NASA's Jet Propulsion Laboratory, (CONTINUED ON PAGE 89)

Wire

A LINK WITH THE PAST

Remember when you and kids in the neighborhood used to hook up a couple of tin cans with string and communicate from across the street? It wasn't fancy but it worked. Today, when uninterrupted communication between moving or fixed stations is so essential, Vitro has developed a link as simple and reliable as the old tin can technique. Nothing fancy, just a fault-free wire link system that assures maximum protection against such factors as outside interference, abrasion, jamming and foul weather conditions. Light weight packaging and snarl-free payout combine to make the wire link system, perfected by Vitro, as versatile as it is reliable. ■ In today's troubled world we're no longer playing games, but two lessons we learned from tin cans – simplicity and dependability – are still a very real concern in station-to-station communications.



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CREATIVE ELECTRONICS BY RCA

"WEATHER EYE" IN SPACE

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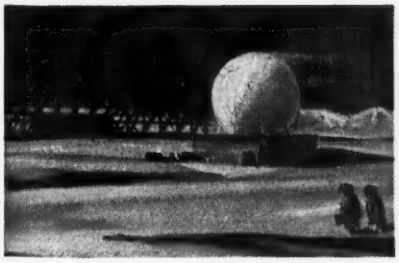
From its vantage point in space, TIROS is sending down to earth new, more definite pictures and data of the world's everchanging weather patterns to aid man in his ageless efforts to control the elements.

Incorporating revolutionary and advanced electronic equipment, TIROS was designed, developed and built by RCA's Astro-Electronics Division for National Aeronautics and Space Administration. Within its small circumference are miniature TV cameras, tape recorders, TV transmitters, command receivers, timing mechanisms, beacons and telemetry equipment. In addition, it carries new scanning and non-scanning Infra-red Sensing Devices, developed by NASA, to measure and record the heat radiation of the earth and its cloud cover, and a revolutionary new Magnetic Orientation Device to capitalize on the effects of the earth's magnetic field and maintain favorable orientation of the satellite for long periods.



BMEWS—RCA Electronics Equipment and Systems contribute to the alert status of the Nation's vast outer perimeter early warning system.

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Solar Spectrum in Space

(CONTINUED FROM PAGE 33)

good accuracy from the visible to about 2000 Å (near ultraviolet). Measurements by Dunkelman and Scolnik of the difficult region from 4000 to 3000 Å obtained from Mount Lemmon, Ariz., are the most accurate available.[3] The absolute energy scale for this part of the spectrum was set by Johnson from a reconsideration of a long program of measurements, conducted by the Smithsonian Institution, and the infrared and ultraviolet corrections. Johnson's value of the solar constant is 2.00 ± 0.04 calorie/cm²/min (1.39×10^6 erg/cm²/sec). The Mount Lemmon data and the rocket spectra to 2000 Å are adjusted to be consistent with this value.

The NRL rocket spectrum has been published by Wilson et al.[5] over the wavelengths 2990 to 2635 Å, and the region 2635 to 2085 Å is covered by Malitson et al.[6] Curves are presented at a resolution of about 0.5 Å, on an absolute energy scale tied to the Mount Lemmon curve.

For many purposes, data with less spectral resolution are more convenient. For this reason the table published by Johnson covered the spectral range to 2200 Å in steps of 50 Å.[4] This table is based on the early NRL rocket data, and is essentially correct to about 2400 Å. Below 2400 Å, the data are low, by a factor which reaches about 2 at 2200 Å.

The region from 2000 to 500 Å (extreme ultraviolet) has been studied by NRL using normal-incidence grating spectrographs and photographic recording. On April 19, 1960, the latest in a long series of flights, a new type of spectrograph was employed. The background of instrumental stray light, so long the factor which limited the accuracy of the results, was eliminated by the use of double dispersion. The two photos on pages 32 and 33 show two portions of the newly recorded spectrum. Everything recorded was real solar emission at the indicated wavelengths.

Regions of Emission

The new record shows that throughout this region the sun radiates a continuous spectrum, with emission lines superimposed upon it. This is unlike the visible and near-ultraviolet, where the continuum is crowded with intense absorption lines and there are no emission lines. The extreme ultraviolet originates from higher levels in the sun's atmosphere than does the near ultraviolet and the visible. The extreme-ultraviolet continuum probably comes mainly from the very low chromosphere. The emission lines come from the region above the limb, where the temperature increases from 5000 K in the low chromosphere to 1 million K in the corona.

The exact region of emission depends on the particular line. For example, the many lines of neutral carbon (C I) must come from low in the solar atmosphere, since carbon is rather easily ionized. On the other hand, the resonance lines of seven-times ionized neon (Ne VIII) at 770 and 780 Å must be emitted from the corona only, since a temperature of the order of 1 million K is required to produce such a high state of ionization.

A most significant feature is the intense Lyman-series emission from hydrogen, the most abundant element in the sun. This series has its first line, Lyman alpha, at 1216 Å. This line carries about 6 erg/cm²/sec energy to the earth during times near sunspot maximum; the radiation may be considerably less at sunspot minimum. Lyman alpha delivers more energy than the entire extreme ultraviolet and X-ray spectrum shortward of itself. The higher members of the series are indicated in the photo on page 32, and are followed by the Lyman continuum.

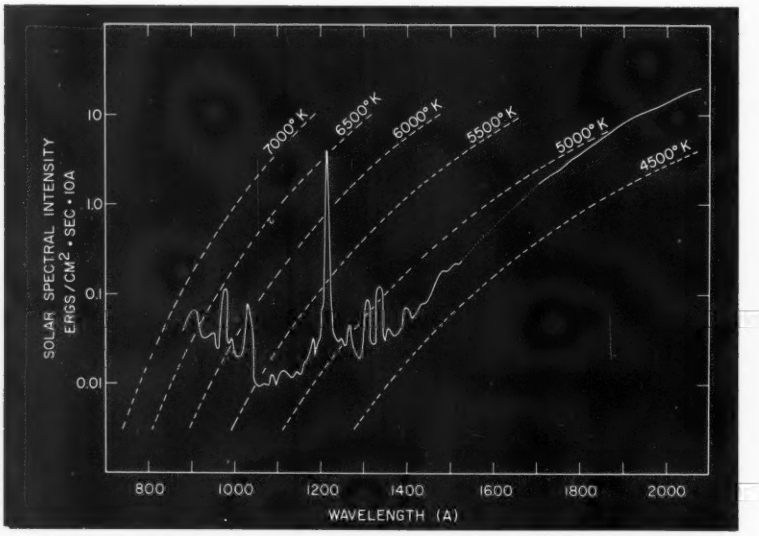
The best spectral intensity curve from 2000 to 870 Å resulting from the work of NRL appears below left. The vertical scale gives the energy incident per cm²/sec in a 10-Å wide wavelength interval (outside the earth's atmosphere). The NRL data were actually obtained at 10-times greater resolution, but were averaged over a 10-Å interval before plotting to remove the great detail and thus make them easier to use.

The solar spectrum follows a 5000 to 4700 K black-body curve from 2085 to about 1300 Å, with certain emission lines superimposed. Then the continuum rises rapidly toward Lyman alpha, and falls again on the short-wavelength side, but never to as low a black-body temperature as above Lyman alpha. From 1040 to 912 Å, the spectrum consists principally of emission lines, which are not resolved in the 10-Å plot. There is, however, considerable energy here, and it contributes to E-layer dynamics by ionizing O_2, whose ionization limit lies near 1027 Å. Below 912 Å, the Lyman continuum of hydrogen is the most important emission. It follows a 6700-K black-body curve.

In obtaining these data, it was necessary to correct for absorption by water vapor in certain spectral regions, for example, the strong bands near 1120 Å, visible in the photo on page 32. The water vapor is believed to have been carried with the spectrograph and not exhausted rapidly enough to the nearly perfect vacuum outside the rocket.

Measurements of the solar-intensity distribution are also being made by Hinteregger of GRD with a completely different technique; grazing-incidence grating monochromators with photoelectric scanning are flown in Aerobee-

The Extreme Ultraviolet in Space



The radiation outside the earth's atmosphere from the entire sun in the extreme ultraviolet to 870 Å, from the work of Detwiler, Purcell, and Tousey of NRL. The resolution of the original spectra has been reduced to 10 Å for easy use.

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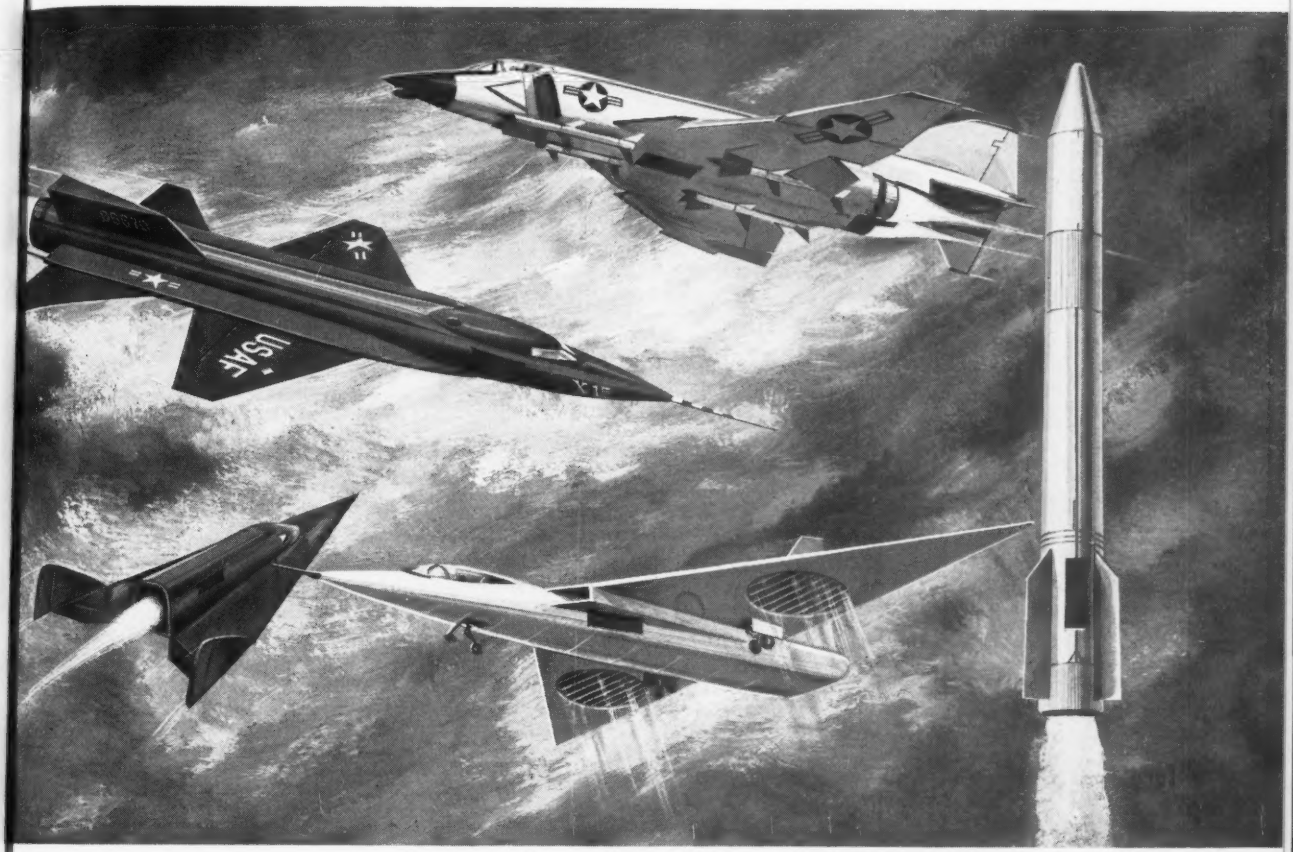
. . . LEADERSHIP IN AERO/SPACE ELECTRONICS



GESAC

New flight control system is fully self-adaptive, performance-proven in flight testing

A whole new flight spectrum of manned and unmanned vehicles is at hand. To meet the unique range of control requirements of these vehicles, General Electric now offers a completely new type of flight control system, called GESAC. (General Electric Self-Adaptive Control.)

A knowledge of the detailed aerodynamic characteristics of a missile or aircraft is not required to apply GESAC to the vehicle. Thus, both flight testing and application engineering effort can be sharply reduced.

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GESAC has already been successfully flight-tested aboard the Convair F-106 under Navy Bureau of Weapons sponsorship. An evaluation of extremely rigorous re-entry profiles has been conducted on the North American/NASA X-15 Simulator under Air Force contract, with outstanding success. A flight evaluation on the McDonnell F4H-1 is currently in progress under Navy BuWeps contract. GESAC provides another example of Light Military Electronics Department leadership in aero/space electronics.

150-03

GENERAL ELECTRIC

Light Military Electronics Department

Armament & Control Section, Johnson City, New York

Hi rockets. This method gives data to very short wavelengths, because of the use of grazing incidence and the high reflectance it provides; but the resolution is lower than with photographic spectroscopy. The latest results[7] over the wavelength range 1300 to 870 Å agree reasonably well with the NRL data, and are lower than the results of the first flight.[8]

The data obtained by Hinteregger covering the wavelengths 800 to 60 Å show that there is intense emission at 584 and 304 Å from neutral and ionized helium, respectively.[8] The two lines produce of the order of 0.5 erg/cm²/sec at the earth. Also present are other lines, and a rather intense background that may consist largely of unresolved lines. Some true continuum is also present, for example, the He II continuum below 228 Å.

Within the X-ray region, data are available from NRL. The graph of solar X-rays at right gives a summary of the results obtained by Friedman, Chubb and their associates.[9] The measurements were made using photon counters of known spectral response. Additional spectral information was obtained by studying the rate of attenuation of the signals with altitude, using the atmosphere itself as a spectral analyzer.

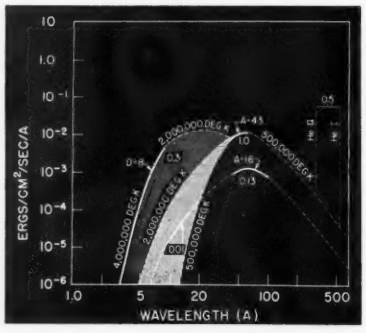
Features of a Quiet Sun

The quiet sun, during periods near sunspot maximum, emits an X-ray flux roughly as shown in the graph, and produces a total emission of about 1 erg/cm²/sec. The broad features of this emission can be approximated by a superposition of gray-body emission curves. The bulk of the X-ray energy is emitted in the longer wavelengths—i.e., 20 to 100 Å—and this emission can be conveniently described by a 500,000-K gray-body curve. In addition, there is a short wavelength tail which follows an approximately 2 million-K curve.

An X-ray photograph of the sun, obtained with a pinhole camera, shows that the X-rays originate largely in coronal condensations associated with active regions on the sun.[2] During nonflare periods, X-ray emission is negligible below 5 Å. Also, the total X-ray flux shows large variations with the solar cycle, the total emission varying by a factor of five between solar minimum and solar maximum. The variation in X-ray intensity increases toward shorter wavelengths, so that X-rays of less than 15 Å show a solar-cycle variation of a factor of 30.

The changes in radiation during solar flares have been the object of much study by Chubb and Kreplin at NRL.[9] Rockets have been launched during flares to observe the changes in

The Solar X-Ray Spectrum



radiation. More recently, Satellite 1960 $\eta 2$ launched on June 22, 1960, contained X-ray and Lyman-alpha solar monitors.[10] The data from 1960 $\eta 2$ confirm the earlier rocket results, which showed that the short-wavelength X-ray intensity increases greatly during flares. The Lyman-alpha line, however, is not noticeably affected.

The solar X-ray spectrum on this page shows a curve obtained during a small flare (Class I). The intensity below 20 Å increased, and radiation was detected to about 3 Å. During intense flares, however, the change is much greater. Hard X-rays of wavelengths as short as 0.1 Å were detected during one Class II+ flare on Sept. 1, 1959. This very high energy emission is again a tail on the X-ray spectrum emitted by the flare, and contains only a small portion of the total flare emission.

The attenuation of these radiations by the earth's atmosphere is a study in itself. Most of the radiation suffers little absorption above 200 km, and the X-ray end and Lyman alpha penetrate far below 100 km. However, certain wavelengths are absorbed at very high altitudes indeed. Perhaps the highest is the very center of the Lyman-alpha line. The high resolution spectrum of this line, obtained by Purcell and Tousey,[11] shows an absorption core produced by neutral hydrogen in the exosphere, at a temperature of 1000 to 2000 K; some of the hydrogen may also be in interplanetary space.

The possibility of absorption by gases carried with vehicles should not be overlooked. For example, in the photo on page 32, there can be seen strong absorption bands produced by water vapor. This is water carried with the rocket. Thus vapors released from the vehicle may have an important screening action. In all probability, a considerable time in orbit would be required before a large vehicle would be completely gassed out.

To conclude, we can give a rough guide to the intensity distribution in the short-wavelength end of the solar spectrum, as it traverses free space at the distance of the earth:

λ (Å)	Fraction of total solar energy below λ
7000	0.5
4000	0.1
3000	0.01
2400	0.001
1900	0.0001
1600	0.00001
1000	0.000001

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11. Purcell, J. D. and Tousey, R., *J. Geophys. Res.*, vol. 65, p. 370, 1960. ♦♦

Russian Lunar Atlas Made Available

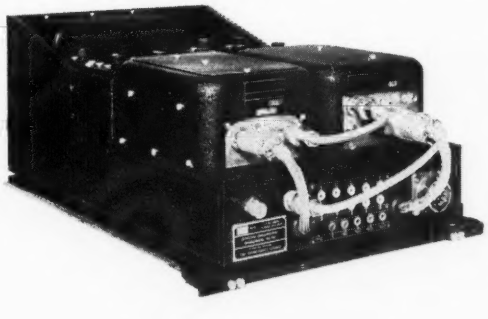
The lunar atlas prepared by the USSR Academy of Sciences from Lunik III pictures has been made available in English through the Dept. of Commerce (OTS) and the Air Force (order 61-21955 from OTS, Dept. of Commerce, Washington 25, D.C., $3.00).

New Timing System For Standards Bureau

The National Bureau of Standards has added Sperry Gyroscope Loran-C equipment to its facilities at Boulder, Colo., to synchronize and set clocks in various places to within 1 microsec. The new equipment will add to the preciseness of meteorological and space observations.

THE VOICE OF THE "FIREBEE"

Ryan uses airborne telemetry systems by DORSETT



Near-sonic, Ryan's Q-2C "Firebee" Target Drone provides a fast, high-flying, evasive target simulating combat tactics. Rugged and recoverable for reuse, the "Firebee" is daily putting the "test of fire" on American airborne and surface-to-air missile systems.

Firebee can be precisely controlled from airborne or ground stations, since in addition to radar tracking data, engine r.p.m., airspeed and altitude are telemetered continuously to the controller by the Dorsett Model TM-4-31 system.

When additional data is required for missile development programs and special applications, the system may be expanded to a total of ten subcarrier oscillators in the pre-wired chassis.

The Firebee telemetry system is one of the many designed and built by Dorsett Electronics. Put Dorsett's experience to work for you on your next telemetry requirement. Your inquiries and specifications will receive a prompt reply.

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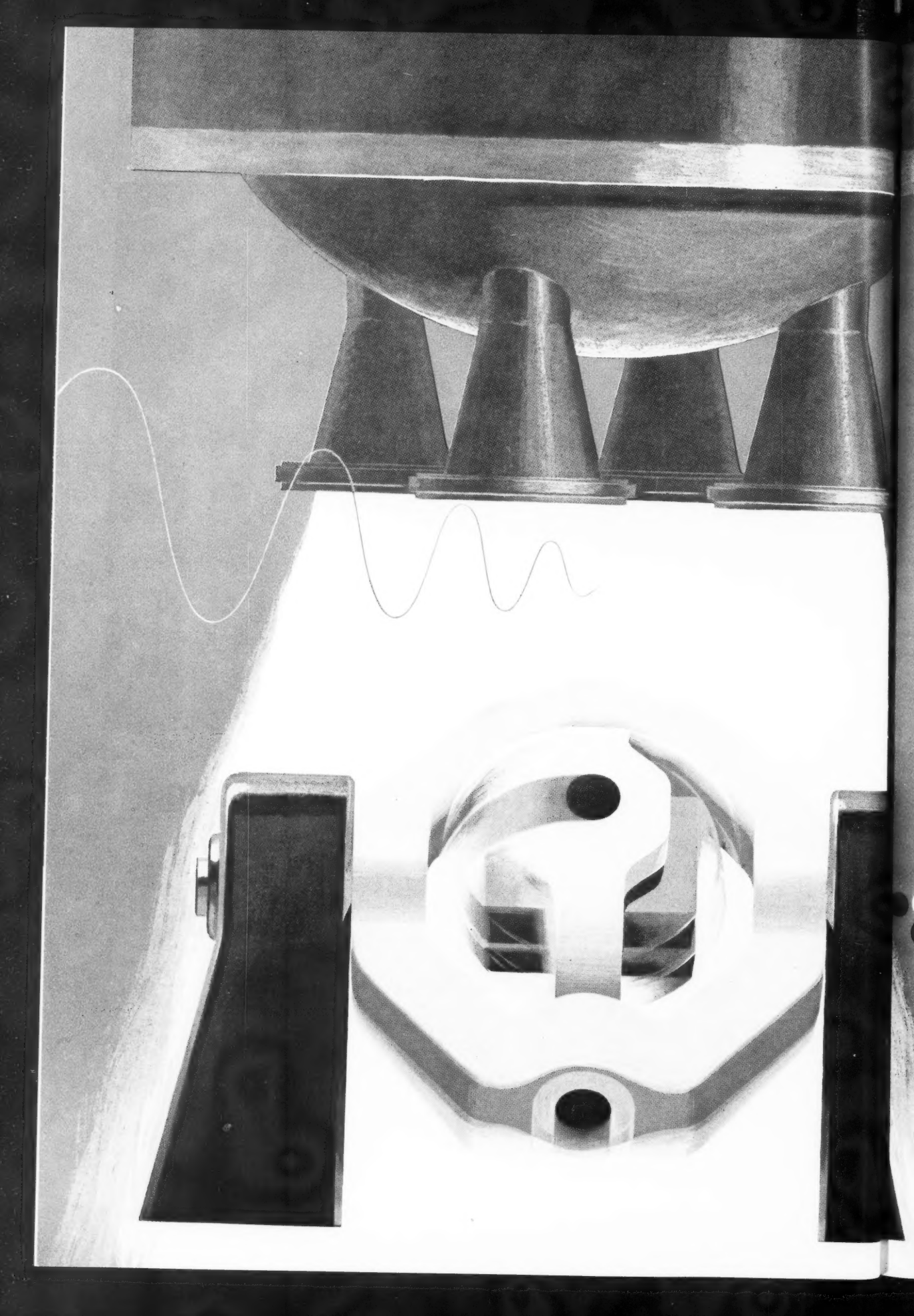

LABORATORY LAUNCH PAD

"In-house" missile flights are a daily occurrence at Lockheed Missiles and Space Division. The advantages of "flying" the POLARIS FBM inside the laboratory, on an amazing internally-developed simulator, are obvious.

The simulator performs many developmental and test functions. When the missile is first conceived, performance charecteristics are cranked in; basic overall requirements are read out. Later, the simulator details the functional requirements of each subsystem and calculates specifications for hydraulic, electronic and pneumatic hardware. As each component is built, it replaces its computer counterpart.

Finally, the whole guidance and flight control package is put through simulated flights for final checkout. But that isn't all. The simulator also performs the role of post-flight evaluation detective when it is fed tapes of actual flights, and the effects are observed on earth-bound hardware.

It is with such elaborate equipment, guided by engineers and scientists of outstanding calibre, that Lockheed Missiles and Space Division has attained its place in the forefront of missile and space technology. And such progress is constantly creating key positions for other engineers and scientists of proved ability, so they may take up the exciting challenges offered by Lockheed and share in its rewards.

This unusual organization is located in Sunnyvale and Palo Alto, on the San Francisco Peninsula in California. For an informative brochure, "Your Place in Space," write to: Research and Development Staff, Department M-31A, 962 West El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required. All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS Programs

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Careers in astronautics

By Irving Michelson, *Illinois Institute of Technology*

QUESTIONS about the existence of life on other planets have found a highly promising forum within the astronautical community. New knowledge in the biological and chemical areas, in conjunction with the perfection of technological means for performing tests and measurements in deep space, has set the stage for an immensely important joint effort by life scientists and space technologists. Narrowing the search to Venus and Mars, research teams have lately gained a reasonably definite notion of what tests are required and how the findings will bear on crucial questions confronting their colleagues in virtually every branch of the natural and physical sciences. At a time when intrinsic cultural values of space research are being strongly emphasized at the national level, these studies are due to win a prominent place, demanding an unprecedented scale of interdisciplinary scientific collaboration.

* * *

We can identify some of the new faces in astronautics, necessitated by this development, by tracing the discoveries, deductions, and inferences which have advanced the effort to its present aspect. Of first importance among these, according to CalTech's biologist Horowitz, is the recognition that nucleic acids and proteins are the basic unique materials of all living matter as we know it. On the cosmologist's assurance that high polymer molecules of these types, and even the elements which compose them, cannot have existed forever, the search turns to conditions under which they might evolve. A major step in this area was Harold Urey's discovery that a large variety of complex organic material is produced when a spark discharge passes through a primordial hydrogen-dominated atmosphere.

Logically, the next question is: Where in our universe are (or might once have been) conditions favorable to spontaneous generation of something as complicated as a protein molecule by random chemical combination? The planet Mercury, nearest to the sun, is first easily ruled out because of its lack of atmosphere and very great extremes of hot and cold on its illuminated and dark sides, respectively. Next distant from the sun is Venus, our nearest neighbor planet, being approximately the same size as earth and having much carbon dioxide in its atmosphere, but also having temperatures perhaps considerably in excess of those at which known important biological substances decompose. Unfortunately, astronomical observations of Venus have always been thwarted by its darkness when it is near us and its excessive distance (on the far side of the sun) when it is illuminated. The impenetrable clouds which shroud Venus when it occupies intermediate positions have prevented us from observing the surface of the planet. Obviously, it is most important to determine these temperatures before conducting any more delicate tests, so that undue efforts will not be applied where simpler observations might establish a negative result. Temperature measurement is sure to be a prime assignment for the first spacecraft which approach Venus, and anyone with ideas on thermal measurement instrumentation packaging for such a mission will find a very willing audience these days.

The distinct advantage of solar-sail techniques for Venus missions is already well known, and a big development effort on such vehicles finds strong justification here. Materials and space-navigation techniques are two areas of particular importance in this regard. Meanwhile, we can watch for new launch techniques to facilitate Venus shots—maybe even fixed-angle, long-launch-track arrangements, Russian style, which our programs have bypassed until now.

* * *

Although Mars shots will be more difficult because the direction is away from the sun, for earthlings, Mars is in many ways the most intriguing planet from the standpoint of the search for living organisms. Astronomers see its illuminated side easily enough, and we know that daytime temperatures there are quite moderate, though the thinness of its atmosphere results in rather cold nights. Surface pressures are also not drastically different from what we know on earth. It becomes even more fascinating when polar caps are reported, which might indicate the presence of snow, and hence of water, on that planet. Finally, and most important, are the seasonally changing dark areas, increasing in size with the approach of summer. These form the chief piece of concrete and direct evidence that life exists on planets other than earth. Geographers are not really satisfied with explanations of why the dark areas move *away* from the poles in springtime, just opposite to the pattern followed on earth. Can it be that plants grow, and grow first near the poles where melting ice concentrates during the winter? The question which confronts plant physiologists in this connection is: What is the simplest way of identifying vegetation remotely?

Spectroscopists have found the same absorption bands that belong to organic substances in light coming from the dark areas of Mars. This strengthens the idea that carbon compounds are to be found there, perhaps living. Giant, swirling clouds of dust have been observed, too, which do not obscure the dark areas when they settle out, further suggesting that active vegetation may be present. Before costly Mars missions are undertaken, the theoretical meteorologist and hydrodynamicist should offer some explanations of these effects—which they may venture to do when more is known of the mechanics and stability of the dust-devils frequently seen in our own deserts. Finding answers to these questions, and many more, is important before Mars exploration is attempted by space vehicles of any sort.

* * *

It would also be very valuable to have more complete spectroscopic analyses of radiations from these planets than we have so far been able to get at the earth's surface. Satellites and balloons, out beyond much or all of our own atmosphere, could give us important information on the composition and temperatures of other planetary atmospheres. This would indicate, for example, how much ultraviolet reaches those planets, and hence the possibility of accumulating significant amounts of organic matter.

Advocates of these programs point out that a single positive finding, establishing the existence of life on other planets, would be a scientific discovery of momentous significance surpassing the greatest achievements of the twentieth century. Nobody we know seems inclined to dispute this assertion.

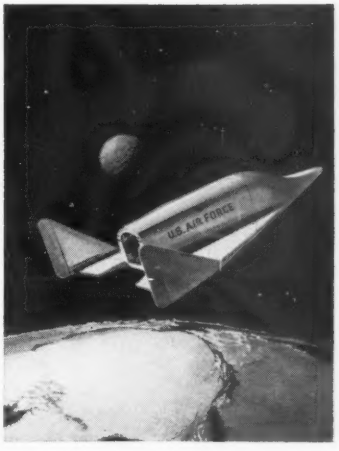
For specific career opportunities see pages 1, 61, 69, 87, 91, 95, 97, 99, and Third Cover.

♦♦

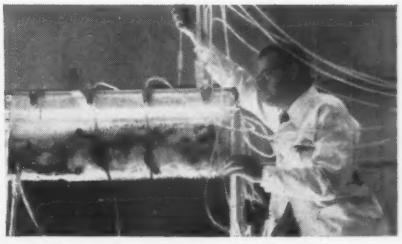
TWIN-TURBINE HELICOPTER. The Boeing-Vertol 107—fastest, smoothest-riding commercial helicopter now flying—goes into service with New York Airways this summer. It seats 25 passengers in comfort, cruises at 155 mph and has built-in flotation for water landings. The 107 is now undergoing FAA certification testing. It has been ordered for service in Japan, Canada and Sweden. A special version was winner in recent competition for a U.S. Marine assault transport helicopter.

Capability has many faces at Boeing

JET-AGE FIRE FIGHTER. Boeing gas turbine engines power fire trucks in San Francisco and Seattle. These 330 hp engines weigh only 335 pounds, propel 15-ton trucks from standing start to 25 mph in 9 seconds.



SPACE GLIDER. Drawing of U.S. Air Force's Dyna-Soar manned space glider, designed to rocket into space, then re-enter the earth's atmosphere for conventional pilot-controlled landing. Boeing is system contractor for Dyna-Soar.



OXYGEN FOR SPACE. Boeing space medicine research includes growth of green algae for conversion of carbon dioxide into oxygen in space vehicles. In test, a Boeing researcher has lived 56 hours on algae-produced oxygen in sealed space chamber, proving potential of carbon dioxide-algae-oxygen cycle.

BOEING

D-A, V-A Sounding Rockets

(CONTINUED FROM PAGE 39)

in the adapter. Although close tolerances of mating parts in the interstage adapter are not required, rigid radial alignment may be maintained, while forward axial motion is unrestrained. Thus, separation is caused by differences in drag-to-weight ratio of the two stages when the first stage burns out.

Available payload volumes are adjusted by varying both nose diameter and length. This is the reason for presenting performance as a function of nose gross weight rather than payload weight. A typical weight of the nose hardware, including timer and batteries for second-stage ignition, is 6 lb. Nose outside diameters of 3.0, 3.25, and 3.5 in. have been flown; canister lengths have varied from 16 to 30 in. The batteries and the acceleration-initiated mechanical timer for igniting the second stage and performing other desired functions are usually located in the 10-deg conical nose cone. Some payload geometries require other arrangements. A three-caliber, tangent-ogive nose cone is sometimes used to increase internal volume without a corresponding increase in drag.

Even though the vehicle reaches flight speeds close to Mach 6 at second-stage burnout, aluminum can be used for all hardware; the altitude at this time is near 50,000 ft, and thus heat inputs are relatively low.

Aerodynamic parameters were first deduced from flight tests and were later measured in various wind tunnels. The second-stage vehicle tests were conducted in the Jet Propulsion Laboratory's 20-in. supersonic wind tunnel and in Sandia's Scarf III transonic wind tunnel. The two-stage V-A configuration was tested in the Naval Supersonic Laboratory's wind tunnel at the Massachusetts Institute of Technology over the transonic and supersonic Mach regimes.

Flight Testing

Flight testing was done at the AEC's Tonopah (Nev.) Test Range, which Sandia operates. In addition to ballistic telemetry records, flight data were obtained from Fastax-camera coverage and ballistic-camera tracking. Trajectory data were obtained both from the Sandia Midot tracking system (Multiple Interferometer Determination of Trajectory), which utilizes the telemetry signal, and from supplemental Askania tracking. The trajectories of the chaff rockets had to be deduced from the chaff acquisition points.

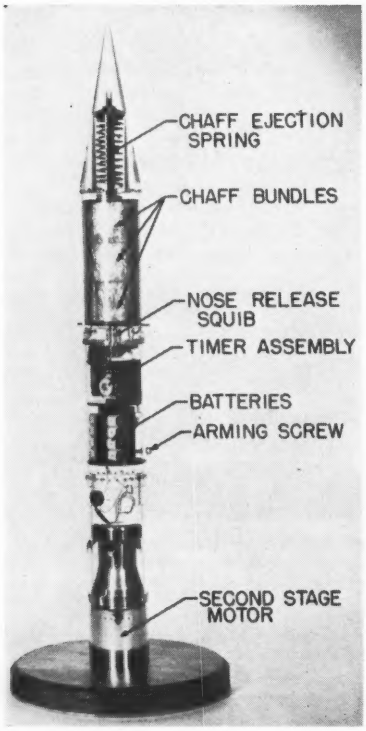
Operational units have been flown at Tonopah and from several sea-level locations in the Pacific. In addition, the Army has recently flown several rounds from the East Coast.

As might be anticipated in a development program which was pushed to completion in spite of obstacles and time limitations, many difficulties were encountered on early flight-tests. Only the two most unusual problems will be noted here.

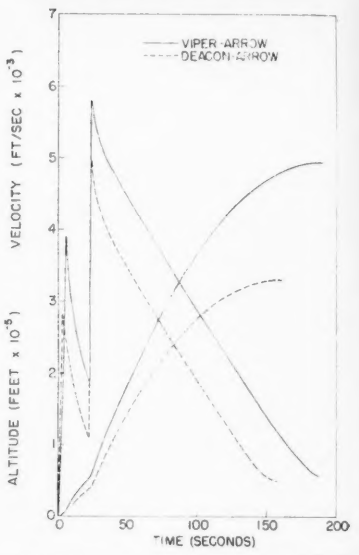
First, although roll-pitch coupling was carefully avoided when the roll rate was selected, shaft coupling was encountered and the roll rate had to be changed. The difference between the two is that roll-pitch coupling is a resonant phenomenon experienced by a slightly unsymmetrical rigid body when the roll rate is close to the natural pitch frequency of the system, whereas shaft coupling is a resonant condition encountered by a slightly unsymmetrical flexible body when the roll rate is approximately equal to the natural bending frequency.

The other condition encountered was a deceleration instability. The coefficients of the equations of motion of a vehicle about its center of gravity are not constant but change rapidly during flights under high accelerations. Consequently, if damping is small, conditions may be such that the motion of a vehicle about its center of gravity can converge or diverge regardless of whether the static-stability parameter is negative or positive. In this case the vehicle was actually slightly unstable at second-stage burnout but, because of the rapidly increasing dynamic pressure and decreasing moment of inertia, it appeared stable up to the time optical coverage was lost at second-stage burnout. Thereafter the dynamic pressure was decreasing and, according to a theory developed at the time, the

Transparent Model of Chaff Head

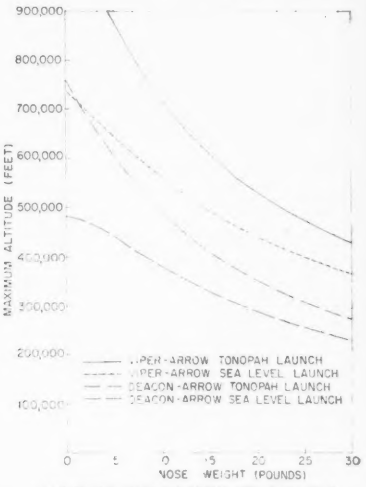


Altitude and Velocity Vs. Time

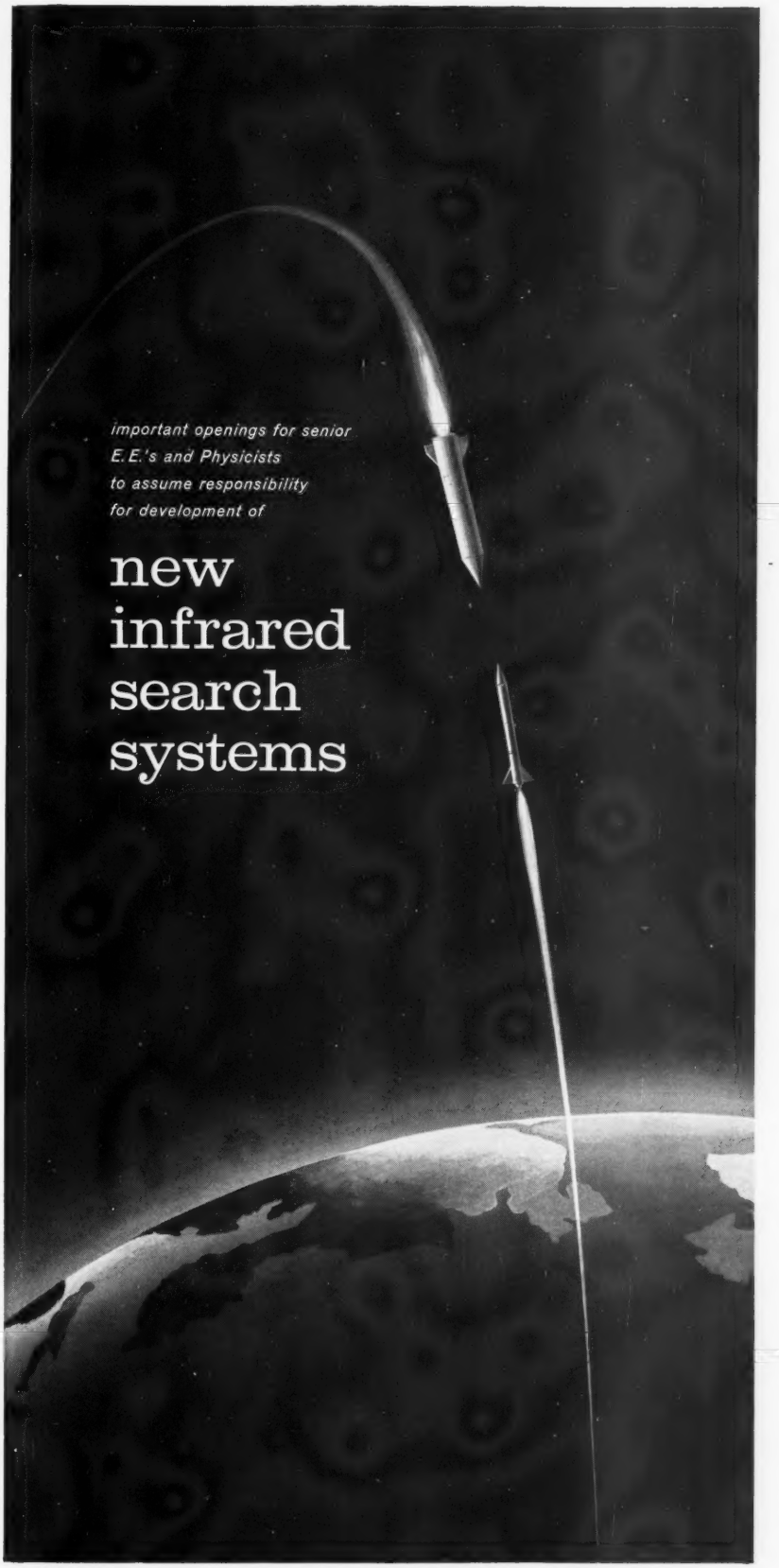


NOMINAL D-A AND V-A TRAJECTORIES

Noseweight Vs. Apogee Altitude



ALTITUDE CAPABILITIES OF THE D-A AND V-A SOUNDING ROCKETS



Progress of the Hughes Infrared Systems and Guidance Heads Department reflects Hughes' overall growth. In the past ten years, employment has risen from under 2,000 to over 30,000 in semi-autonomous divisions concerned with Engineering, Research, Commercial Products, Ground Systems, Communications and Manufacturing. The infrared activity includes these typical projects:

1. **Air-To-Air Missiles**
2. **AICBM**
3. **Air-To-Air Detection Search Sets**
4. **Satellite Detection & Identification**
5. **Infrared Range Measurement**
6. **Detection Cryogenics**
7. **Detector Application Physics**
8. **Optical Systems Design**

These activities have created a number of new openings for graduate engineers and physicists with analytical and inventive abilities.

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Nominal Deacon-Arrow Sensitivities*

Independent Variable	Dependent Variable: Apogee Altitude	Range to Apogee	Time to Apogee
First-stage weight	−2067 ft/lb	−253 ft/lb	−0.45 sec/lb
Second-stage weight**	−9413 ft/lb	−2088 ft/lb	−2.20 sec/lb
Launch elevation angle	2315 ft/deg	−15963 ft/deg	0.60 sec/deg

* Range to impact = 1.96 x range to apogee; time to impact = 1.97 x time to apogee.

** A change in second-stage weight implies the same change in launch weight.

motion diverged. Then, as the Mach number dropped, the vehicle again became statically stable and at the same time the rate of change of the dynamic pressure greatly decreased. As a result, the motion again began to converge, and the vehicle recovered and went on to an altitude which was only about half the predicted altitude. The obvious solution was to increase the static stability. Wind-tunnel data, when used later in the program, apparently substantiated this thinking.

Three-dimensional trajectories were computed on an IBM 704. The optimum second-stage ignition time was determined to be 22 sec after launch. Trajectory parameters are presented graphically on page 60, and are for a nominal flight unless otherwise noted. A nominal flight is from sea level with a launch angle (Quadrant Elevation) of 86 deg, a second-stage ignition time of 22 sec after launch, and a nose gross weight of 15 lb. The drag coefficient for a 3.25-in.-diam nose without antennae was used on the D-A runs. The higher drag coefficient of a 3.5-in.-diam nose with antennae was used to compute the V-A trajectories. And also note that approximately 25% more altitude is attained by a rocket launched from Tonopah (MSL elevation: 5300 ft) than from sea level.

Launch Weight, Angles

In many instances, it has been impossible to determine launch weights and angles before going to the field. To enable predictions of small deviations from a nominal flight to be made in the field, trajectories were computed varying individually the first-stage weight, second-stage weight, and launch-angle (Q.E.) parameters. The maximum (apogee) altitude, time-to-apogee, and range-to-apogee values were cross-plotted against the weight and Q.E. parameters, and then the slope of the cross-plotted curve at the nominal weight and Q.E. values were determined graphically.

This slope, which has been termed a sensitivity, is essentially a partial derivative. It indicates, for example, the effect of varying first-stage weight on maximum altitude. Using sensitivity values, the accumulative effect on the trajectory of simultaneous deviations from the nominal first-stage weight, second-stage weight, and Q.E. can be immediately ascertained. As an indication of representative sensitivity values, the sensitivities of the Deacon-Arrow chaff rocket are presented in the table above.

A superior characteristic of this system, as well as a primary disadvantage, is the high fineness ratio of the second-stage vehicle. This ratio, which is about 28, results in a very high ratio of weight to the product of drag coefficient and drag area (W/C_DA) during the coasting phase before second-stage ignition. As a result, much of the energy imparted to the second stage by the first stage is conserved as kinetic and potential energy of the system rather than expended through drag, and the performance of the system is thus increased. The corresponding disadvantage is that the payload cross-sectional area is severely restricted.

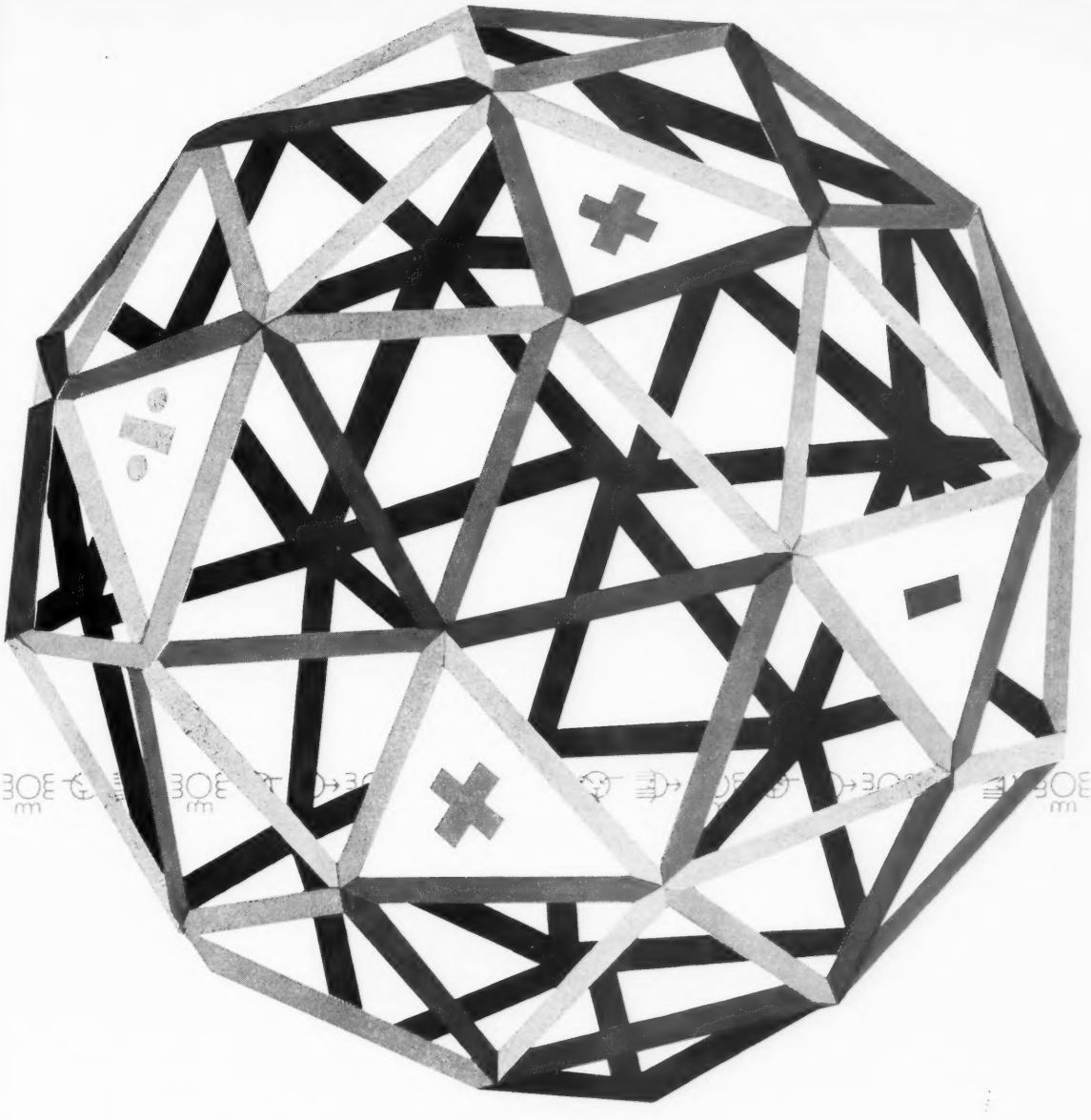
Two Types of Launchers

Two types of launchers have been used—one zero-length, with a Q.E. adjustable continuously between 60 and 90 deg and an azimuth adjustment of ±8 deg, and one a rail, with 2.5 ft of effective guidance (from which both shoes detach simultaneously) and Q.E. adjustment from 60 to 90 deg but azimuth easily changeable 360 deg. Large azimuth adjustments are highly desirable if the launcher is to be corrected for winds when high Q.E. angles are used. Although some were successfully launched at Q.E.'s from 68 to 90 deg, the majority of the rockets were launched at 86 deg.

The rockets require only a minimum of field facilities for assembly and launching. Providing that the weather will permit and assuming that the background radio-frequency radiation level is low enough so that a shielded assembly building is unwarranted, assembly can be done on saw-

Approximate Costs of D-A and V-A Rocket Systems in Quantities of 25–50 Units

Hardware	
First-stage fin assembly	$400
Second-stage fin assembly	150
Interstage adapter	250
Rocket motors	
X-220 A-8 Deacon	$1200
Viper I	1750
Arrow II	500
Chaff nose assembly	$550
Launcher	
Zero length	$ 800
Rail with rotating base	2500
Total Costs	
Deacon-Arrow System (not incl. nose)	$2500
Viper-Arrow System (not incl. nose)	3050
Deacon-Arrow Chaff Rocket	3050



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horses at the launch pad in a few minutes. This assumes that the nose assembly requires only checkout and mating to the second-stage motor in the field.

A bracket-and-block-and-tackle assembly (a gallows) is temporarily attached to the top of the launcher and is used to hoist the first stage on the launcher. The second stage is manually lifted and placed in the interstage adapter. A lightweight portable scaffold is employed during final checkout and arming of the second stage. The launcher is usually corrected for zone winds immediately before arming the propulsion units.

Flight-Test Conditions

Some conditions under which vehicles have been successfully flown include steady surface winds of 25 to 30 knots, highly gusty rain squalls, and second-stage ignition occurring in a 170-knot jet stream. Dispersions noted after field wind corrections have a one-sigma limit (68%) of about 45 mills. This value includes the error in predicting winds at flight time.

Although blowoff cables are used to turn on and to calibrate telemetry, no external connections to the second-stage firing circuit are necessary. This circuit is completely internal within the second stage and is initiated by first-stage acceleration. Thus, aside from telemetry controls, the firing circuit need consist only of power leads to the first-stage igniter.

The Deacon-Arrow and Viper-Arrow are the cheapest known sounding probes in their class. The table on page 62 gives a cost breakdown for the two rocket systems. It should be noted here that Sandia Corp. is operated on a nonprofit basis and is not in the business of selling sounding rockets. Thus the costs mentioned are not quotes at which Sandia will furnish rocket probes nor do they include any profits (other than the profits on hardware fabrication and commercial components) or development costs. Sandia will be happy to furnish design information to governmental agencies desiring to make use of these systems.

Future plans include replacing the chaff in one head with an inflatable Mylar sphere containing a corner reflector. Although the sphere's rate of descent will be higher than that of the chaff, the radar target will not disperse, and density, as well as wind velocity, can be obtained. In addition, various transducers to measure high-altitude phenomena have been or are scheduled to be carried in the standard vehicles; it is anticipated that some payloads will be recovered. A one-year synoptic study of winds between 200,000 and 300,000 ft was completed in October 1959.

As has been previously noted, off-the-shelf rocket motors were used by Sandia, and hardware was designed to be compatible and reliable. Undoubtedly performance could be improved by redesign of the hardware for lower weight. This, however, would increase costs; and since the improvement in performance is of marginal interest, no redesign is planned for the future.

The Deacon-Arrow and Viper-Arrow rocket systems are felt to be versatile, highly reliable sounding probes capable of penetrating into the lower parts of the F-layer of the ionosphere. Designed for simple field application, they are economical both in dollars and cents and in energy expended to do a given job. Their high reliability should also be considered in cost comparisons. These rocket probes can be valuable tools for simple experiments on limited budgets, at altitudes within the capabilities of the vehicles.

The total number of rounds flown as of March 1, 1961, is 174 D-A's, 23 V-A's, and one each Cajun-Arrow and Kisha Arrow. After development was completed, the rocket performed normally 93% of the time.

The D-A is still proving to be the workhorse of the group; the reason for this is its high reliability. Aeroelastic failures have been encountered on some of the higher performance vehicles. Increasing the wall thickness of the Viper motor from 0.042 to 0.092 in. apparently has corrected this problem; however, this observation is based only on the record of six of the last seven V-A's performing satisfactorily. Two of these successful rounds carried 36-in., 21-lb nose packages. In addition to the standard aluminum Arrow motors, steel-cased Arrows have been manufactured and are being used on rounds where the lower performance is either acceptable or desirable. Twelve steel Arrows have been flown and all have performed satisfactorily.

A first-stage assembly has been developed under Sandia specifications as a replacement for the Deacon. The successful bidder on the project was Rocket Power/Talco, who named the replacement motor the Kisha. Overall, the Kisha is approximately 40 in. shorter than the Deacon. Assembly of the first stage has been simplified; the basic interstage adapter design was not changed, although the weight and drag of the adapter were reduced considerably. Theoretical performance of the Kisha-Arrow is approximately 20% greater than that of the D-A. Only one K-A has been flown to date; however, this round performed as predicted and the system appears promising.

A new telemetry package developed by Vector Mfg. Co. is very compatible with the Arrow system. The transistorized transmitter is 2.65 in. in diam by $1^1/_2$ in. long and the mixer and subcarrier oscillators are wafers 2.65 in. in diam by $^3/_8$ in. long. The telemetry operates directly from 28 DC. The D-A and V-A systems were used on some early phases of an upper atmospheric research program which was conducted jointly by the Los Alamos Scientific Laboratory and Sandia. Instruments which have been flown include electron spectrometers, both boron trifloride and lithium iodide neutron counters, sodium iodide gamma counters, Bennett ion probes, and proton telescopes. A Servomechanisms-developed densitometer incorporated in a Sandria baro probe design has also been flown on the D-A. The system appears very promising for determining pressure, density, and temperature from 50,000 to 250,000 ft. In other recent applications, the D-A has been used to determine winds from 225,000 ft down to 70,000 ft by replacing the usual mylar chaff with 5 mil copper chaff.

A new launcher has been designed for these small rockets and will be placed in operation at Tonopah within a few months. This launcher, which can be loaded horizontally and elevated remotely, can be set in both azimuth and elevation at any time just prior to launch from the firing blockhouse. This remote setting capability will be used in conjunction with the existing 300 ft wind tower at Tonopah, and thus the launcher can be corrected for surface winds approximately a minute before launch.

Suggested Additional Reading

Force, C. T., "Range Safety Considerations of the Deacon-Arrow Sounding Rocket," Sandia Corporation Report, SC-4513(RR), 1961. Also available from OTS and OTIE.

Force, C. T. and Walker, W. E., "Design Characteristics and Performance of Sandia's Deacon-Arrow Chaff-Rocket System," *Sandia Corporation Report SC-4229(TR) 1958.* (Available from the Office of Technical Services, Department of Commerce.) ♦♦

Handbook on Thermophysical Properties of Solids Out

A five-volume handbook of thermophysical properties of solid materials has been completed by the Armour Research Foundation, and is being issued as WADD Technical Report 58-476, as well as in hardback form by Macmillan. Materials include elements, alloys, ceramics, cermets, intermetallics, polymerics, and composites. Except for the last two categories, only materials melting above 1000 F are covered.

FROM ITT'S PAST—TOMORROW'S ANSWER TO

COMMUNICATIONS UNDER ANY CONDITIONS

Consistent with its policy of thinking and working years ahead, ITT Federal Laboratories has been concerned with the communications problems which might arise in extreme emergencies. That, surely, is when the need for rapid interchange of information would be greatest, and where the system and equipment would have to be absolutely reliable.

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Astronautics from The Ground Up

One of a pair of the nation's largest spherical tanks for storing liquid hydrogen rises at Douglas Aircraft's Sacramento, Calif., field station where the Saturn S-IV (C-1 second stage) will be static-tested. The Saturn S-IV, for which Douglas is NASA prime contractor, employs lox-hydrogen engines.

Aerospace Probing

(CONTINUED FROM PAGE 37)

of aluminum-coated nylon, the balloon is released and inflated at an altitude of 250,000 to 260,000 ft and is then radar-tracked during descent. From the time-space-position data obtained, it is possible to compute wind direction, velocity, density, pressure, and temperature. The 7-ft long Arcas, the smallest test vehicle used to date, is launched from a portable closed-breech, stovepipe-type launcher. It is being developed under an ONR contract, jointly funded by the ONR, Army, and Air Force. The Robin instrument package is an AF development.

A program has been conducted to obtain data on the ambient electrical field, vehicle potential, ambient positive-ion density, and mobility distribution of atmospheric ions. The test vehicle, a Nike-Asp sounding rocket, consists of a Nike-M5 booster as the first stage, an Asp motor as the second stage, and a 68-lb payload. The payload contains a 2-w Bendix FM/FM transmitter operating on 234 mc. An AN/DPN-41 S band beacon is installed for radar tracking, and two flares are mounted on the Asp fins to aid optical tracking. This vehicle has reached a maximum altitude of 675,000 ft in 231 sec, with a total flight time of 440.3 sec and a maximum velocity of 6577 fps at second-stage burnout, 27 sec after launch. Oklahoma State Univ. designed and fabricated the telemetry package for this program.

Aerobee-150 firings are scheduled as part of a basic research program to obtain data on the magnetic-field strength of the upper atmosphere. The program will require launching Aerobee-150 test vehicles carrying instrumentation packages to altitudes of approximately 180 mi. These test packages will contain experimental instrumentation and a telemetry system to relay data to ground stations. The test vehicles will be equipped with DPN-41 S-band tracking beacons and a DRW-11 receiver for command shutoff of fuel for the second stage.

Nike-Cajun test vehicles have been launched to obtain data on micrometeorite size and density in the upper atmosphere. The tests required launching of Nike-Cajun's carrying 50-lb instrumentation packages to an altitude of 95 mi. W-111A tracking flares were installed on the test vehicle for acquisition and photo-optic tracking.

A Cree program has been conducted to establish the feasibility of trailing aerodynamic decelerators for the recovery of re-entry vehicles, missiles, emergency-escape capsules, nose cones, and drones operating at high Mach numbers and high altitude. Nike boosters were used to accelerate 200- to 800-lb test packages to velocities up to Mach 3.0 at 150,000 ft. When the desired altitude and velocity were attained, the test package separated from the booster engine to act as a decelerator test unit. To obtain test data, each unit was equipped with a high-speed camera to photograph decelerator deployment, instrumentation to determine air pressure and shock loads, and a telemetry transmitter. The vehicles were equipped with S-band radar tracking beacons, sea-air rescue and homing transmitter, and flotation gear and dye markers to facilitate tracking and recovery of the test equipment. The test vehicles and payloads were prepared by Cook Research Co. under a WADD contract.

A Firefly program was conducted to obtain data on artificial ionized clouds created by chemicals released at altitudes between 90 and 150 km. The chemicals included salts of cesium, sodium, and barium and carbon tetrachloride. On some occasions, high explosives were used to create shock waves. These launchings were mostly at predawn to permit better photographic coverage of ionized clouds, which were illuminated by the morning sun while the cameras were in darkness. Nike-Cajun test vehicles were used to propel 50-lb payloads to the required altitudes. A communications network covering points in Florida, Texas, Alabama, Louisiana, Mississippi, California, Washington, Massachusetts, and Maryland was utilized to coordinate the instrumentation of observers at these locations. Stanford Univ., Georgia Institute of Technology, and Georgia Univ. worked under AF contract on this program.

The Tattle Tale program was conducted to evaluate the functional reliability of a long-range UHF communication system transmitting from a high-altitude rocket platform. Aerobee-300 vehicles were used to carry a 47-lb payload of communications equipment (recorder, modulator transmitter, preamplifier, exciter, batteries, relays, and antenna) to an altitude of approximately 300 mi. The rockets were equipped with DPN-41 S-band beacon for radar tracking and a DRW-11 destruct receiver. A network of widely separated ground and air monitoring stations were used to receive and record the transmissions from the UHF positive-control communication system under test. Hughes Aircraft performed the experiment under AF contract.

The Astrobee-500 test vehicle is now being tested in connection with a program for the development of a long-range geodetic survey technique by the Air Force Cambridge Research Center. The test vehicles will be equipped with instrumentation to provide data on acceleration forces, temperatures, velocities, and other vehicle-performance data. They will carry DPN-41 S-band tracking beacons and tracking flares to assist in photo-optic tracking and radar acquisition. A peak altitude of 525 mi and a range of 510 mi is predicted for this vehicle.

Range Instrumentation

The Aerospace Facility on Santa Rosa Island uses a comprehensive range instrumentation system. Five major sites located along Florida's west coast at Eglin AFB, Cape San Blas, Anelote Point, Marco Island, and Cudjoe Key (near Key West) comprise the Eglin Gulf Test Range. These stations are connected by a microwave troposphere-scatter communication system for transmission of

radar, telemetry, countdown, range status, and operational data. A timing system accurate to $^1/_4$ millisec serves the entire range.

Time-space-position data is provided by radars, phototheodolites, and ballistics cameras positioned strategically at the five major stations covering the 400-mi-long Florida west coast. The system includes eleven AN/FPS-16, three AN/MSQ-1, five AN/MSQ-1A, two modified Nike, and five AN/MPQ-31 radars. Ten ballistic cameras—three mobile Wild BC-4's, four Peerless, two aerial, and one modified K-47—are in use. Seventeen Contraves and 12 Askania phototheodolites are installed in the vicinity of Eglin and Cape San Blas for optical coverage of early portions of the vehicle trajectory.

Site A-20 of the Eglin Gulf Test Range, located near the Aerospace Facility, has been established as Station 17 of the Project Mercury global instrumentation system. It will operate as a radar-tracking site utilizing FPS-16 and MPQ-31 radars. Both radars have had recent acquisition and range-extension modifications to improve their capability of tracking an object in orbit.

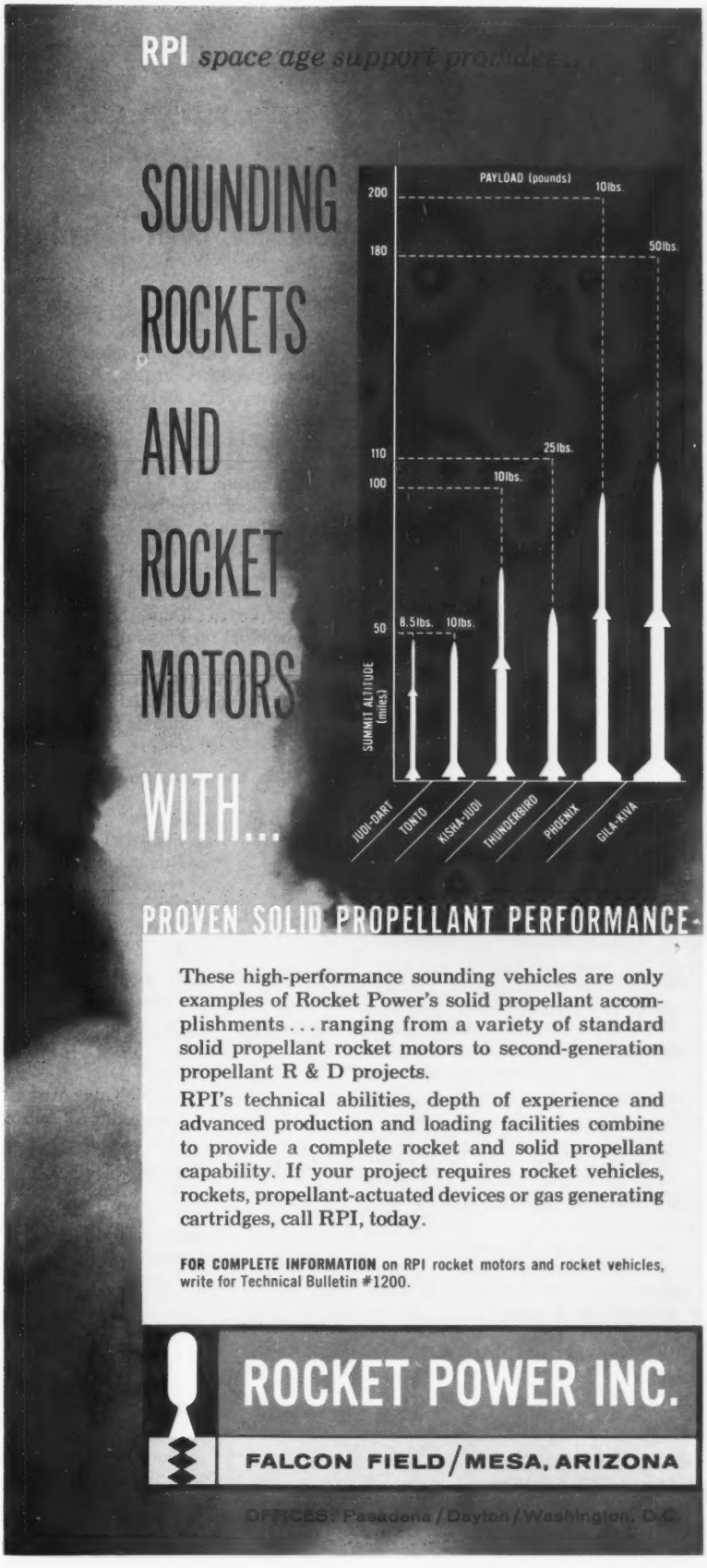
Ballistic Computations

Ballistic computations for rocket impact, probability dispersion distances on all stages, and time-trajectory information—such as altitudes, velocities, accelerations, positions, and look-angles—for the range instrumentation are furnished by APGC ballisticians.

The IBM 704 multistage rocket program, IBM 650, ERA 1103, and ERA 1103A computing machines provide additional support information. The programmed equations include 5 deg of freedom (the spin about the longitudinal axis being supplied to the computer in tabular form) and consider all major effects on the rocket trajectory. Dispersion studies include the effects of thrust misalignments, structural misalignments, tower-angle errors, wind effects, and other perturbing factors.

Prior to the time of launch, project personnel are given corrected launch angles to account for the latest winds. This insures that the rocket obtains the desired altitude and lands in the desired impact area. Impact predictions are corrected for wind conditions until the final readings about 10 min before launch.

The majority of the aforementioned programs are under the cognizance of the AF, NASA, WADD, and ARPA. Other organizations have also completed or are planning use of the Aerospace Facility for launchings. ♦♦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ARS news

ARS Specialist Meeting on Guidance, Control, and Navigation Coming Next Month

A PROGRAM of approximately 80 technical papers has been arranged for the ARS Specialist Meeting on Guidance, Control, and Navigation to be held at Stanford Univ. Aug. 7–9, 1961. The papers will be presented in 15 sessions, five of which will be classified. The titles of the classified sessions are as follows:

"Inertial Guidance Systems for Ballistic Missiles and Space Probes," "Current State of the Art of Gyroscopes, Part I," "Current State of the Art of Gyroscopes, Part II," "Current State of the Art of Accelerometers," and "Exotic Inertial Components."

This conference will permit attendees to discuss both theoretical and experimental aspects of components and systems and the latest developments in this area. Since much of the information on state of the art of gyroscopes, accelerometers, and other components is classified, it was decided that these topics could not be adequately discussed without making certain sessions classified.

In addition, there will be open sessions on optical techniques for guidance; optical, doppler, and radio systems for space navigation; space-vehicle attitude sensing and control; guidance and control theory; injection and re-entry guidance; orbital operations; and planetary probes, solar probes, and lunar-landing systems. There will also be a session on navigation systems for ships, submarines, and aircraft. It is believed that these sessions will cover most of the aspects of guidance, control, and navigation for both ballistic missiles and space vehicles.

The conference is being sponsored by the ARS Guidance and Control Committee, of which James S. Farrior is chairman, by Stanford Univ., and by the Northern California Section of ARS. Don DeBra is chairman of the committee for local arrangements. The program chairman for the conference is Donald P. LeGalley of Space Technology Laboratories, Inc., and the vice-chairman is Robert H. Cannon Jr. of Stanford Univ. Session chairmen and vice-chairmen who are connected with national programs in this field. have been selected to organize the sessions, review and select papers, and preside at the meetings.

After the conference, selected papers will be published in the ARS Progress in Astronautics and Rocketry Series under the editorship of Robert E. Roberson of the Guidance and Navigation Committee.

In addition to the formal sessions, arrangements have been made to have the following luncheon speakers: Charles Stark Draper, director, MIT Instrumentation Lab; Helmut Schlitt, Bell Aerospace Co.; and L. I. Schiff, head of Physics Dept., Stanford Univ. The banquet on Tuesday night will be addressed by John Moore, vice-president of Autonetics, on "The State of the Art of Inertial Guidance."

The sessions schedule follows:

Monday, Aug. 7

9:00 a.m.	Planetary Probes, Space Probes and Lunar-Landing Systems Space-Vehicle Attitude Sensing Control, Part I
12:00 noon	Luncheon Speaker—Charles S. Draper
2:00 p.m.	Current State of the Art of Gyroscopes, Part I Space-Vehicle Attitude Sensing and Control, Part II
7:30 p.m.	Current State of the Art of Gyroscopes, Part II Special Topics in Guidance and Control Theory

Tuesday, Aug. 8

9:00 a.m.	Current State of the Art of Accelerometers Adaptive Control System Optical Techniques for Guidance
12:00 noon	Luncheon Speaker—Helmut Schlitt
2:00 p.m.	Inertial-Guidance Systems for Ballistic Missiles and Space Probes Optical, Doppler, and Radio Systems for Space Navigation
7:00 p.m.	Conference Banquet—John Moore

Wednesday, Aug. 9

9:00 a.m.	Injection and Reentry Exotic Inertial Components
12:00 noon	Luncheon Speaker—L. I. Schiff
2:00 p.m.	Orbital Operations Navigation Systems for Ships, Submarines and Aircraft

—D. P. LeGalley

Intl. Hypersonics Conference Set for August 16–18 at MIT

The American Rocket Society's first specialists meeting in hypersonics, co-sponsored by the Air Force Office of Scientific Research, will be held at the Massachusetts Institute of Technology on August 16 to 18. A top-level technical program has been planned covering hypersonics research problems of major current interest. Specific session topics cover low Reynolds Number problems, chemical kinetics effects, and inviscid hypersonic flow problems. In addition, two sessions will be devoted to the numerous experimental facilities and techniques that have been developed in the last few years for hypersonic research.

It is hoped that the meeting will be highlighted by active participation of scientists of the USSR. A complete session has been allocated for the presentation of Russian papers. Interest has been expressed by the USSR to participate in the meeting, although a definite session program has not yet been established.

This hypersonics meeting is directed toward providing a forum for

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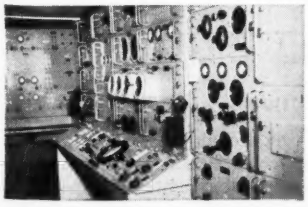

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scientific discussion of research problems associated with very-high-speed flight in the atmosphere. Current rising interest in manned space vehicles is pointing up the need for accelerated research in many of these areas.

The topics of the sessions scheduled are as follows:

Wednesday, Aug. 16

9:00 a.m. Hypersonic Flow at Low Reynolds Number

2:00 p.m. Experimental Techniques I

Thursday, Aug. 17

9:00 a.m. Chemical Kinetic Effects in Hypersonic Flow

Friday, Aug. 18

9:00 a.m. Inviscid Hypersonic Flows

2:00 p.m. Experimental Techniques II

400 Attend Propellants, Combustion, And Liquid Rockets Conference

The ARS Propellants, Combustion, and Liquid Rockets Specialist Conference, held at the Palm Beach Biltmore Hotel in Palm Beach, Fla., April 26–28, drew an attendance of more than 400. Some 35 technical papers were presented at eight Technical Sessions at the meeting.

Topics covered at the six unclassified sessions were detonation phenomena, detonability of propellants, boiling and near-critical heat transfer, two-phase flow on propellant performance, propellants and combustion, and lag processes in rocket nozzles. The latter was a panel discussion moderated by Sol S. Penner of the Guggenheim Jet Propulsion Center of Cal Tech.

Two classified sessions were also held at the meeting. One, a Secret session, was devoted to radiation from rocket exhausts. The other, classified Confidential, discussed destructive instability in liquid rockets.

Morning and afternoon sessions were held the first day of the meeting, and morning and evening sessions were held on the second day, leaving the afternoon free for attendees to take advantage of the Florida sunshine.

The conference banquet took place on the first evening of the meeting, and was preceded by a reception sponsored by the Pratt and Whitney Aircraft Div. Banquet toastmaster was Charles T. Roelke, general manager of Pratt and Whitney's Florida R&D Center at West Palm Beach. The banquet speaker was Elliot Mitchell, Assistant Director for Propulsion, NASA Office of Launch Vehicle Programs, who discussed the NASA propulsion program. He noted in his address that the next generation of U.S. space vehicles would depend primarily on lox-hydrogen systems for propulsive power, and that the U.S. appears to be ahead of the USSR in the development of such systems at the present time.

The third day of the meeting, which was co-sponsored by the ARS Propellants and Combustion Committee, headed by Peter L. Nichols Jr. of Stanford Research Institute, and the ARS Liquid Rockets Committee, chaired by Martin Goldsmith of Rand Corp., was devoted to an all-day tour of the Pratt & Whitney R&D Center and the Air Products, Inc., liquid hydrogen plant at West Palm Beach.

Drs. Nichols and Goldsmith were Technical Papers Chairmen for the conference, while Charles H. King Jr. of P&W was the conference General Chairman. Papers presented at the meeting are being evaluated for possible publication in a volume of the *ARS Progress in Astronautics and Rocketry* series.

About 40 of those attending the meeting took advantage of the special Nassau Post-Conference Excursion arranged by the ARS Meeting Department. —I.H.

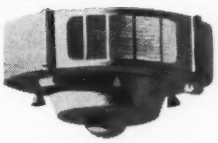
Martin Goldsmith, Chairman, ARS Liquid Rocket Technical Committee (left), and Peter L. Nichols Jr., Chairman of the ARS Propellants and Combustion Committee (right), who acted as Technical Papers Co-Chairmen for the Conference, chat with General Chairman Charles H. King Jr.

Charles T. Roelke, general manager of Pratt and Whitney's Florida R&D Center at West Palm Beach (left), who acted as toastmaster at the banquet, makes a point in a discussion with Elliot Mitchell of NASA, the banquet speaker (center) and Charles H. King Jr.

Members of the ARS Section Activities Committee, which met at the conference, gather at reception. From left to right, Geoff Potter, ARS Membership Manager; Emerson W. Smith of North American; Committee Chairman and ARS Director William J. Cecka Jr. of Rocketdyne; Robert C. Truax of Aerojet; and Rod Stewart of NASA's Marshall Space Flight Center.

Correction

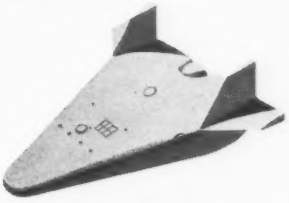
The gentleman shown congratulating junior astronauts Depp and Marks in the news story entitled "Spaceship Simulator on the Mars Scene" on page 74 of the May *Astronautics* is Frank W. Godsey Jr., president of Electronic Communications, Inc., St. Petersburg, Fla., and not R. A. Ibison, as indicated in the caption.



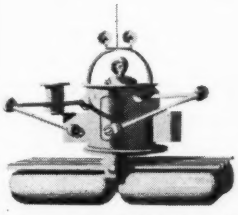
Lunar VTOL Vehicle. A rocket-propelled craft designed to collect lunar ore specimens.

Nuclear Space Ship. An unconventional design by Douglas with living quarters around the ring at the bottom. On landing, it would ease down, ring first.

Nuclear Space Ship. A Douglas design for a space ship with crew quarters and control rooms in the nose, nuclear reactor in the rear.



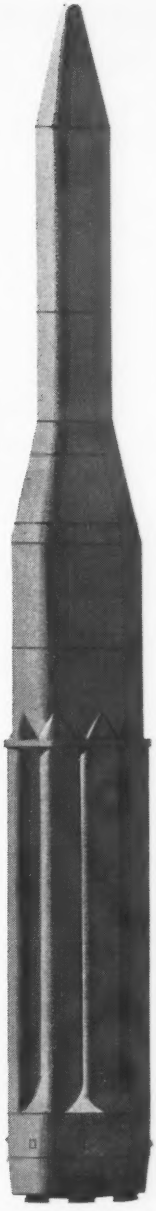
Supply and Escape Vehicle. A compact re-entry vehicle to supply orbiting space stations or to return crews to earth.



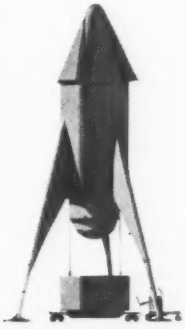
Lunar Service Vehicle. Travels like a "swamp buggy" on inflated rollers. Mechanical arms provided to handle outside chores.

Nuclear Space Ship. A future, medium-thrust, nuclear-electric space ship for one-year interplanetary round trips (Martian and Venusian).

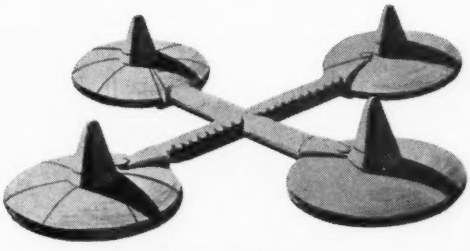
Douglas Thor. Designed as a military IRBM, this dependable missile is the workhorse of the Space Age.



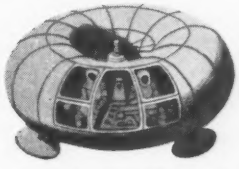
Saturn. First U.S. vehicle designed to put tons of payload into orbit . . . or onto the moon. Douglas-built second stage is as tall as a 4-story building.



Lunar Cargo Handlers. Would load lunar ore samples into containers to be towed back to earth by rockets.



Space Observatory. Sections of this Douglas-designed space station would be sent into space in rockets and be joined together in orbit.



Lunarmobile. Donut-shaped exploration vehicle to use rocket power in space and tractor treads on the moon's surface.

Eleven ways to outwit the law of gravity

When the Space Age dawned, Douglas was ready with specific proposals for space equipment either completed or in advanced stages of development. (Some appear above.)

These Douglas proposals were based on *realistic* estimates of the capabilities of men and materials. They are the valued dividends of the company's considerable experience, gained from the design and production of 30,000 missiles and rockets. These include the Douglas *Thor*, an IRBM which has been totally successful in 86% of its tactical and space firings over the past two years.

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National Telemetering Conference Probes Standards

Over 900 engineers and scientists attended meetings and workshop sessions and wandered through a huge exhibit hall at the National Telemetering Conference held at the Chicago Sheraton-Towers Hotel during the week of May 21. Conference Chairman Robert G. Brown of A. C. Spark Plug opened the conference Sunday in the Press Room with a statement pertaining to Russia's manned orbital flight. Brown speculated on the number of unsuccessful attempts that had been made prior to Gagarin's much publicized trip. Brown's conclusion was that Gagarin was the fourth or fifth man placed into orbit by the Russians but the first to successfully complete the trip.

Fifty manufacturers of telemetering equipment exhibited their products in the new Sheraton exhibit hall. The equipment covered transducers, digital and analog encoders, amplifiers, transmitter antennas, tape recorders, receivers, commutators and decommutators, oscillographs, analog-to-digital converters, and specialized test equipment. Several pieces of new equipment were exhibited for the first time. The general trend in current equipment is toward smaller components of modular-type construction. In all cases, the new equipment was completely transistorized and requires less power to operate, less space for mounting, and generates less heat. In airborne equipment, welded techniques and microminiaturization are becoming more and more prominent.

Of the five societies who jointly support the National Telemetering Conference, each exhibited at the convention. The host society this year was the Institute of Aerospace Sciences. The 1962 conference will be hosted by the Institute of Radio Engineers in Washington, D.C. In 1963, the conference will move to Albuquerque, N.M., with the AIEE acting as host; and in 1964, the American Rocket Society will again be host, probably in Seattle. In 1965, the Instrument Society will take the conference to the Midwest.

The theme for the 1961 conference was "Science and Education in Telemetry" and proved extremely successful. Several "firsts" were established in support of the theme. A students' night which attracted approximately 600 Chicago area high school science students took place Monday night, May 22. The students attended a lecture on principles of telemetering by Lawrence Rauch, professor of instrumentation at the Univ. of Michigan, and Lawrence Gardenhire of Radiation, Inc., Melbourne, Fla. A guided tour of the exhibit area completed the evening.

On the following day a special workshop on telemetry education in the 60's headed by W. J. Mayo-Wells was held. The panel consisted of leaders from both the educational and the industrial fields. A. B. Campbell of the American Rocket Society represented Northwestern Univ.; C. H. Hoffman of the IRE, Notre Dame; H. L. Hull of the IAS, Hull Associates; H. S. Kindler represented IAS; R. J. Koopman of AIEE, Washington Univ., and H. S. Kindler represented the ISA. Other panel members included T. M. Linville of General Electric, M. Mason of George Washington Univ., K. B. McEachron of Case Institute of Technology, L. L. Rauch of the Univ. of Michigan, G. Rothwell of the National Science Foundation, and M. Woolman of George Washington Univ. The panel discussed the ability of our educational institutions to meet the current demands of industry and government for trained engineers and scientific personnel. They also discussed future requirements and the need for expansion of our educational facilities to keep abreast of the trends in telemetering for the future.

The Monday morning workshop session on telemetering standards was chaired by A. E. Bentz of Sandia Corp., who is chairman of the NTC Standards Coordination Committee. The panel consisted of nine representatives from the Committee and discussed the needs, requirements, and problems associated with standards.

The panel represented a good cross-section of the field, with representatives from government operating bases such as R. C. Barto, White Sands Missile Range and F. Karabaich, Wright-Patterson AFB. User groups were represented by F. Riddle of the Jet Propulsion Laboratories and J. Parcell of the Goddard Space Center. W. H. Boone of the Dept. of Defense was able to take an over-all view insofar as defense and government operations are concerned, and a contrasting view by industry was presented by L. W. Gardenhire of Radiation, Inc., M. A. Lowy of Gulton Industries, H. Pruss of the Telemetering Corp. of America,

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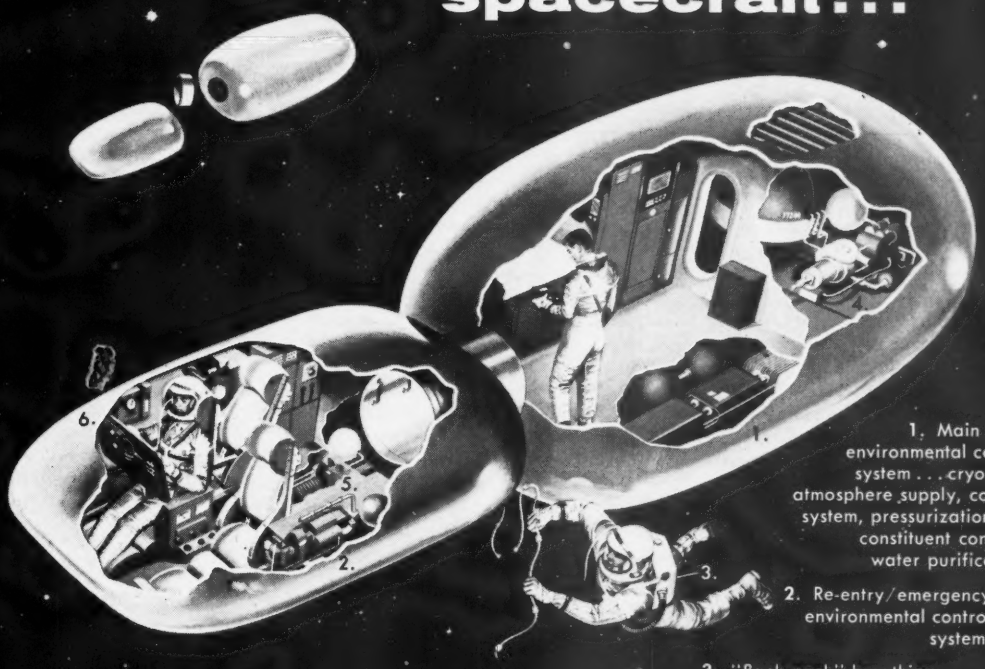
TECHNICAL COMMITTEES AND CHAIRMEN

Astrodynamics, Robert M. L. Baker, Jr.
Communications and Instrumentation, Frank W. Lehan
Electric Propulsion, Ernst Stuhlinger
Guidance and Control, James S. Farrior
Human Factors and Bioastronautics, Eugene B. Konecci
Hypersonics, William H. Dorrance
Liquid Rockets, Martin Goldsmith
Magnetohydrodynamics, Milton M. Slawsky
Missiles and Space Vehicles, William M. Duke
Nuclear Propulsion, Robert W. Bussard
Physics of the Atmosphere and Space, Herbert Friedman
Power Systems, John H. Huth
Propellants and Combustion, Peter L. Nichols, Jr.
Ramjets, William H. Avery
Solid Propellant Rockets, G. Daniel Brewer
Space Law and Sociology, Andrew G. Haley
Structures and Materials, George Gerard
Test, Operations, and Support, Bernhardt L. Dorman
Underwater Propulsion, Herman E. Sheets

Environmental and secondary power systems for multiman spacecraft...



1. Main cabin environmental control system . . . cryogenic atmosphere supply, cooling system, pressurization and constituent controls, water purification.

2. Re-entry/emergency environmental control system.

3. "Back pack" breathing and pressurization system.

4. Secondary power system . . . multiple re-entry turbine, pump, alternator and cryogenic fuel supplies.

5. Attitude control system . . . reaction motor, fuel and attitude controls.

6. Instrumentation . . . flight data and physiological monitoring systems.

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1961 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
Aug. 7–9	Guidance, Control, and Navigation Conference	Palo Alto, Calif.	Past
Aug. 16–18	International Hypersonics Conference	Cambridge, Mass.	Past
Aug. 23–25	Biennial Gas Dynamics Symposium	Evanston, Ill.	Past
Oct. 2–7	XIIth International Astronautical Congress	Washington, D.C.	Past
Oct 9–15	ARS SPACE FLIGHT REPORT TO THE NATION	New York, N.Y.	Past

and R. W. Sanders of Space Electronic Corp. The panel represented a variety of interests, and the variations in interest were brought out in the following discussions between panel and audience:

1. The range and military people tend toward extremely strong and detailed standards, whereas the industrial representatives favor more lenient standards which would allow other than a military application.

2. Statements regarding standardization of space equipment by Fred Riddle of JPL tended to illustrate that not enough is known at this time of the practical applications of optimum techniques for space communications to allow for a rigid standardization program.

3. M. A. Lowy of Gulton Industries and Ray Sanders of Space Electronics put in a strong plea for sensible standards which would not inhibit the development of new ideas and equipment for application to the telemetering problems of the future. Lowy also stressed the importance of recognizing new areas of telemetry application with problems very much different from those experienced on the missile range. Oceanography was listed as one of the primary new areas of this type. Boone, in mentioning that the IRIG standards might come out as a MIL Standard, evoked considerable discussion from the floor and the panel. Enthusiastic participation by the audience strengthened the National Telemetering Conference conviction that present standards are inadequate for today's technology.

Tuesday, May 23, was the date for the presentation of the "Telemetry in Europe Workshop," introduced by Al Gruer of Sandia Corp. and chaired by Dr. Rauch of the Univ. of Michigan. Representatives of eight European countries sat on the panel and discussed their specific problems and their future requirements. A. Cowie of the United Kingdom, described two telemetering systems currently in use in England for missile and aircraft work. G. Fokkinga of the Netherlands disclosed that the primary use of telemetering in his country pertained to measurement of ocean waves and currents to predict wear and tear on the dikes. Other representatives were P. Pelmousos of Greece, R. Refslund of Denmark, M. Astier and M. LaBrausse of France, and F. Alluffi-Petine and A. Dorsimont of Belgium. It appeared that the Europeans are approximately five to eight years behind us in the use of telemetering. However, this situation should be remedied in the next few years through the growth of a new European organization which will be the equivalent of our NASA. Rather than being centered in a single country, the European organization will tend to incorporate the capabilities of all the small European countries into one effort. The European panel stayed for the entire conference and through the use of a special suite had ample opportunity to meet and talk to several hundred United States scientists and engineers. By Wednesday evening, these gentlemen had obtained an entirely new view of this country, its people, customs, and scientific capability. Their presence at the conference did much to increase American prestige abroad.

The annual banquet held Tuesday evening was the scene of the third annual award of "The Telemetering Man of the Year." Eberhardt Rechtin, head of JPL's Telecommunications Div., received the 1961 award for his outstanding contributions to the field over the past five years. Dr. Rechtin has been extremely active in the JPL/NASA space activities, was one of the pioneers of Microlock system, and directs the NASA Deep Space Instrumentation Facility. The main speaker at the banquet was C. Stark Draper of MIT, who discussed the growth of the technology and compared the advance of the state of the art in telemetry with that of inertial guidance.

In all, fifteen sessions were held during the three-day conference covering every area of telemetry. Some of the most heavily attended sessions were PCM systems, underwater measurements, advance system techniques, data processing and presentation, and industrial telemetering. Average attendance at each session was approximately 125 people. There appeared to be an excellent selection of attendees which created spirited discussion at all sessions and many small groups of engineers scattered about the hotel discussing technical problems.

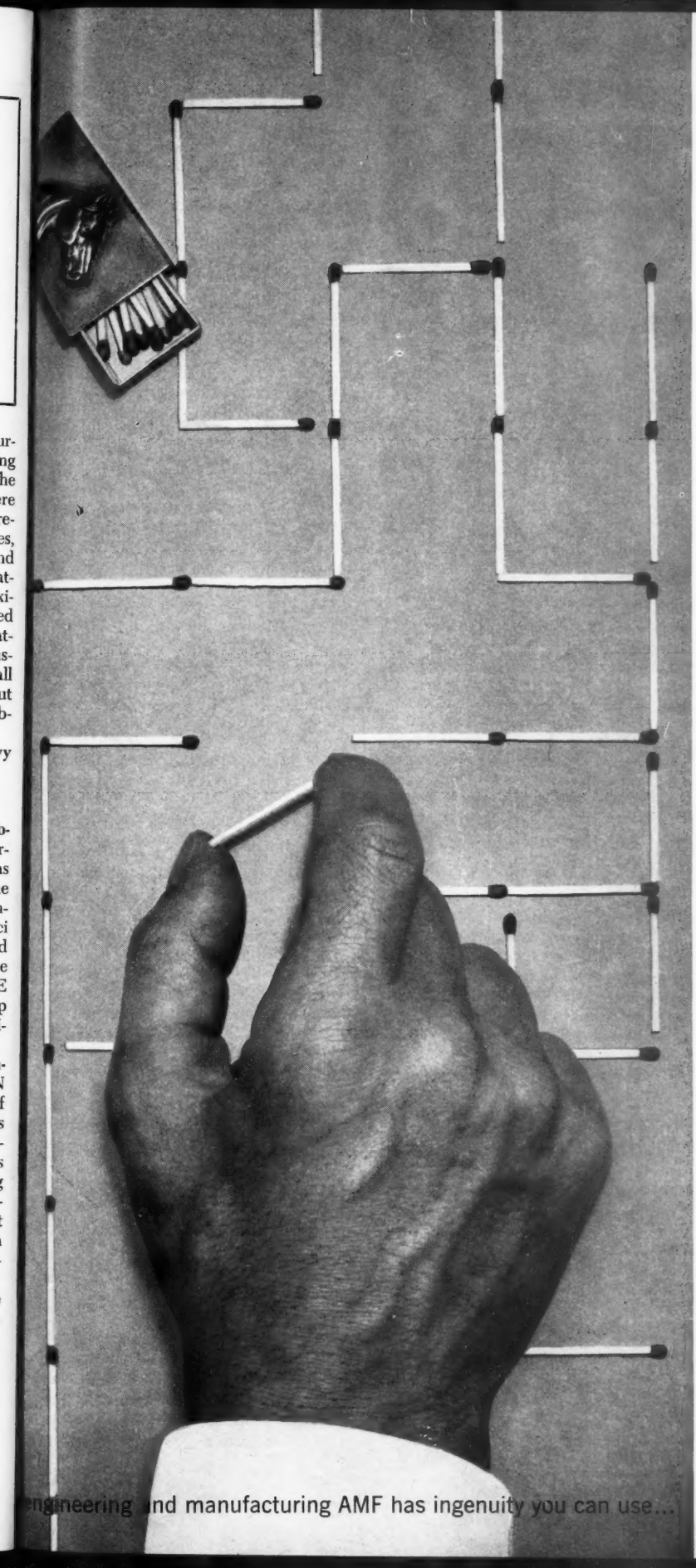
—Max A. Lowy

TECHNICAL COMMITTEES

The ARS Human Factors and Bioastronautics Committee finds its chairman, Eugene Konecci of Douglas, has been elected vice-president of the Aerospace Medical Association. Congratulations are in order. Dr. Konecci reports that the two sessions scheduled by the HF&BA Committee for the SPACE FLIGHT REPORT TO THE NATION appear to be shaping up well, with papers of the highest caliber in the offing.

The Solid Propellant Rocket Committee's two sessions for the SFRN will be chaired by Arch Scurlock of Atlantic Research and H. Griffith Jones of Thiokol's Elkton Div. With proposals and funding for large solids turning firm, these should be exciting sessions . . . Plans for the 1962 Specialists Conference on solid-propellant rocketry appear firmly set now, with papers directed chiefly toward solid-propellant research.

Testing and logistics to advance the nation's large booster program will provide a focus for one of the two sessions sponsored by the Test, Operations, and Support Committee at the SFRN. The Committee's other sessions will review key areas of specialization, such as high-altitude simulation and testing.



He designed a new interchange for radio traffic

This AMF engineer, part of an AMF-U.S. Army team, solved the problem of traffic delays and personal danger in manual re-connection of jumpers when interchanging R.F. transmitters and antennas.

His solution is a push-button-operated, coaxial crossbar switching system, using vacuum switches for circuit selection. A typical system consists of 4 transmitter inputs, 7 antenna outputs plus a dummy load, in a 4 x 8 matrix that can be mounted in a 19″ rack. It can be controlled locally or remotely over any type of communication network having a bandwidth of at least 200 cycles.

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At N.Y. Section Kick-Off Luncheon Meeting

Left to right, Samuel Koslov, Vitro Corp., N.Y. Metropolitan Section vice-president; Edgar M. Cortwright of NASA, the featured speaker; and Section President Joseph G. Gavin Jr. of Grumman chat at first luncheon meeting of the Section.

Hercules Powder Engineers Describe Giant Solid Boosters

Rocket experts, from left, A. F. Giacco, R. E. Young, and J. Scherer, all of Hercules Powder's Chemical Propulsion Div., prepare to discuss their company's approach to solid-propellant rockets powerful enough to send manned spacecraft on lunar and interplanetary missions before a recent meeting of the ARS Greater Philadelphia Section (see Section News).

SECTION NEWS

Columbus: In May, the Section heard guest speaker **Howard W. Douglass,** head of the Hydrogen and Fluorine Section at NASA Lewis Research Center, discuss satellites and science in our lives. Among the benefits he cited were improved weather knowledge, communications, and navigation. Movies of Tiros, the weather satellite, and on the U.S. endeavor in space were shown.

—James J. Komar

Greater Philadelphia: At the May meeting, a team of rocket specialists from Hercules Powder Co. gave the Section a view of what might be done to develop large solid-propellant rocket boosters for the space program. Chief spokesman **A. F. Giacco** of the company's Chemical Propulsion Div. described a Hercules approach to building a solid booster capable of launching a vehicle such as the three-man Apollo spacecraft on lunar or planetary missions. The approach involves a sectional charge made of a number of propellant cylinders each approximately 170 in. in diam, 8 ft long, and weighing about 100,000 lb. The complete rocket would be constructed at the test or firing site by stacking the cylinders one atop the other and then wrapping the entire propellant system with a lightweight case of Spiralloy, a structure spun of glass fibers and bonded with epoxy resin. According to Hercules engineers, this technique achieves the flexibility of the segmented approach and maintains the high mass-fraction potential of the single rocket.

—A. Koch

Holloman: At the April dinner meeting, Section President Harald Von Beckh first introduced J. R. Foote and Maj. Lauritz S. Larsen as new editor and associate editor, respectively, of the Holloman Section Monthly News Bulletin, and then presented the evening's guest speaker, **Frank Denison** of Aeronutronic Div. of Ford Motor Co., who discussed "Lunar Probe Activities." He reviewed U.S. space efforts, outlined the basic objectives and interrelationships of the various lunar and planetary probes—Pioneer, Ranger, Mariner, Surveyor, Voyager, and Prospector—and then gave interesting information on his firm's efforts in the Ranger project with respect to the instrument package which will be hardlanded on the lunar surface. His very interesting presentation was concluded with the showing of a short film on the Ranger concept and some impact tests conducted by Aeronutronic.

—Robert C. Whipple

Indiana: April was a big month for our Section. On April 8, an open house was held at the Purdue Univ. Jet Propulsion Center. Visitors were given a guided tour of the facilities, a description of the equipment, and a review of research being conducted. The movie "Countdown for Tomorrow" and a static firing highlighted the program.

On April 13, the Section held its 11th Annual Banquet at the Fowler-Van Orman Hotel in Lafayette. The banquet commemorated the 20th anniversary of the first manned rocket-powered flight in the U.S. **Brig. Gen. Homer Boushey,** commander of the Arnold Engineering Development Center, "the first U.S. rocket pilot," was to have been the guest speaker, but an illness prevented his attending. He was represented by **Col. F. Flint** of Arnold who gave a very interesting description of the facilities and work being done there. His talk was illustrated by both slides and a movie. Col. Flint accepted for Gen. Boushey a portfolio of pictures assembled in commemoration of the General's JATO-powered Ercoupe flights in August 1941.

On April 20, the Section heard an interesting talk by **J. L. Sanders** of Thiokol's Redstone Div. on "Large Solid-Propellant Motors—The Econom-

Toward a National Perspective in Space

This distinguished panel—from left, D. Hornig of Princeton Univ., K. Knorr of Princeton, C. D. Perkins of Princeton (moderator), E. W. Engstrom of RCA, and R. Jastrow of NASA—gave and took with the members of the ARS Princeton Section recently in a day-long symposium on national perspectives in space (see Section News).

ics of Optimum Space Boosters," in which he described the work being done for NASA in a solid-booster study. He had quite a large number of slides to illustrate some of the many engineering problems anticipated.

At the May meeting, guest speaker **R. W. Ellison** of Martin-Denver discussed new engineering problems encountered in the development of the Titan missile – geysering, destruct-relay chatter, sloshing, and implosion. He presented a description of each phenomena, the failures it had caused, and the steps taken to eliminate them. His talk was accompanied by a movie, taken on the spot at Cape Canaveral and Denver, illustrating failures.

—Mel L'Ecuyer

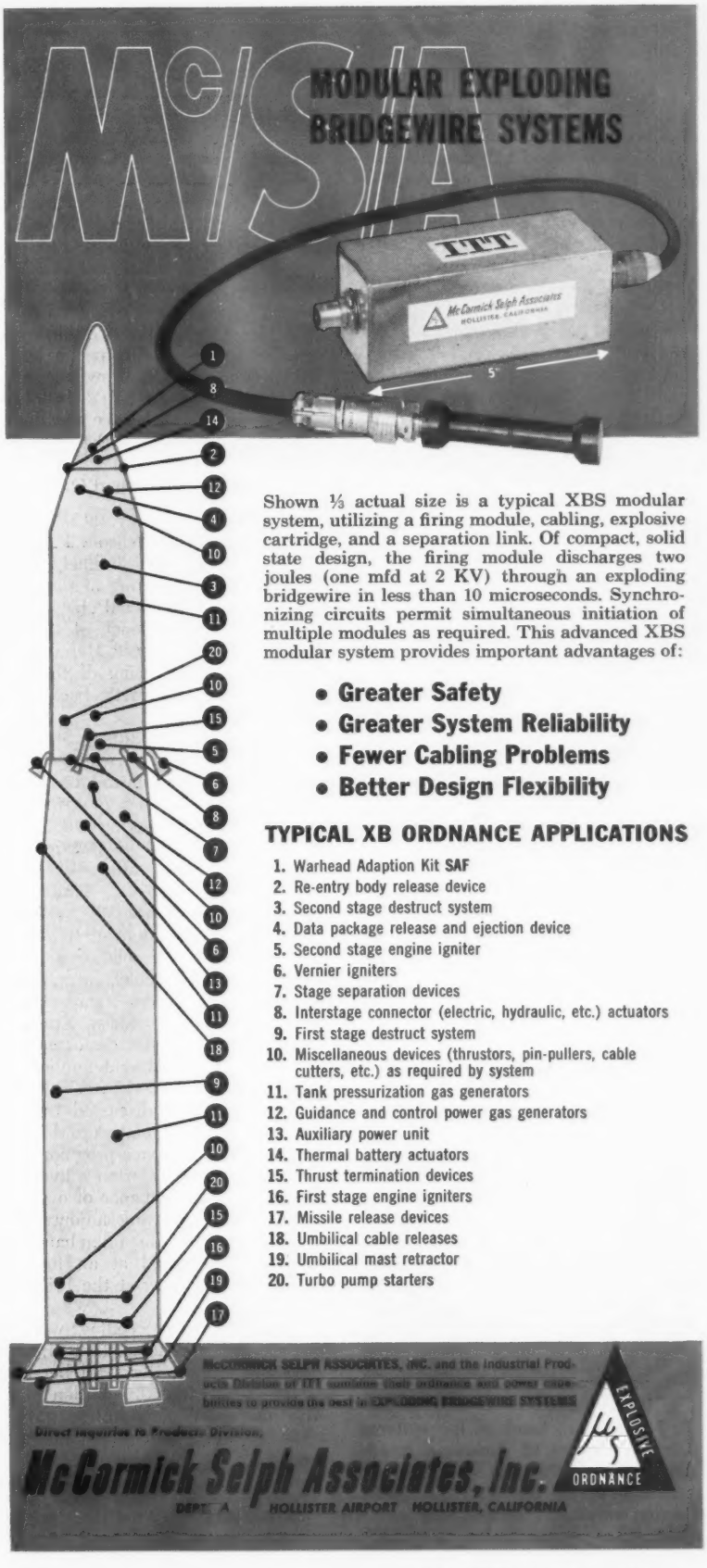
Long Island: At a May dinner meeting, held at the Stratos Div. of Fairchild Engine and Airplane Corp., the Section and guests had the pleasure of hearing guest speaker **Frank W. Lowry,** manager of advanced systems application for Westinghouse Electric Corp., discuss what may be our "Returns from Space." His many interesting comments ranged over worldwide communications and meteorology, clues to the origin of our solar system and life possible through exploration of the moon and planets, and the importance and uses of space programs as propaganda. He illustrated his points with over 100 fine color slides. The dinner and address were preceded by a tour of the Stratos Div. plant.

National Capital: At a luncheon meeting in April, the Section heard **James B. Edson,** senior civilian adviser on missiles to the Army assistant chief of staff for intelligence, discuss "The Growth of Astronautics." Using a prediction method generally applicable to all forms of international competition, Dr. Edson outlined the future of astronautics in terms of probable total payload pounds in orbit and probable total budget. He concluded his talk with the thought-provoking remark that the point at which the U.S. might well take the lead in propulsion capacity could occur when the Soviets make a transition from military to purely astronautic boosters.

—J. Gordon Vaeth

New York Metropolitan: A new series of luncheon meetings planned by the Section got underway with a highly successful event on May 15 that drew an audience of close to 300 people to the Hotel Roosevelt to hear Edgar M. Cortwright, NASA Assistant Director of Lunar and Planetary Programs, discuss future plans of the nation's civilian space agency.

Pinch-hitting for Abe Silverstein of



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4. Data package release and ejection device
5. Second stage engine igniter
6. Vernier igniters
7. Stage separation devices
8. Interstage connector (electric, hydraulic, etc.) actuators
9. First stage destruct system
10. Miscellaneous devices (thrustors, pin-pullers, cable cutters, etc.) as required by system
11. Tank pressurization gas generators
12. Guidance and control power gas generators
13. Auxiliary power unit
14. Thermal battery actuators
15. Thrust termination devices
16. First stage engine igniters
17. Missile release devices
18. Umbilical cable releases
19. Umbilical mast retractor
20. Turbo pump starters

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EXPLOSIVE ORDNANCE

NASA, unable to attend because he was presenting testimony before a Congressional committee, Cortwright offered a succinct but meaty rundown on NASA's plans and programs for the next 10 years, noting that we are on the brink of some fateful national decisions with regard to space. Among these decisions, he went on, were what form the Nova vehicle should take, how to proceed in the communications satellite field, how soon and how much to push for certain programs, and exactly what these programs should be.

He added that there is no question that we are in a space race with Russia, and that both the U.S. and the USSR have chalked up a number of important "firsts." However, he pointed out, there can be no doubt that we are getting better at the business of putting up bigger payloads.

He concluded his talk with a showing of fascinating color movie footage of Comdr. Alan Shepard's ballistic flight in the Mercury capsule. Joseph G. Gavin Jr. of Grumman, president of the Section, was toastmaster at the luncheon.

—I.H.

Northern California: In April, at a joint meeting with the local section of IAS, held in the physics auditorium of Stanford Univ., guest speaker **Ivan Browning,** biophysicist at the Advanced Research Laboratory, Palo Alto, Calif., discussed "Some Principles of Biology and Their Application to Space Technology." The presentation concerned intelligence in biological and machine mechanisms.

Dr. Browning quoted the 4th law of thermodynamics: "Everything being held rigidly constant—organisms do as they damn please!" and then proceeded to illustrate that, despite the perversity of biological systems, their intelligence is remarkable.

Dr. Browning says intelligence is related to the ratio of the number of neurons in the brain to the number of input, or experience, channels. Experience depends on sensory capability, which is roughly comparable to body surface, which can, in turn, be equated with body weight. A "two-thirds ratio rule" of brain and body weight has been developed as a technique for determining equivalent intelligence indexes of living creatures. Man, according to the two-thirds rule, has the highest intelligence index, as anticipated; but Dr. Browning points out that, capable of 9.3×10^{163} possible experiences, the average human brain operates at less than 1% efficiency.

—Robert O. Webster

Princeton: In May, at Princeton Univ.'s Woodrow Wilson Hall, the Section held what will likely be its most significant meeting of the year—a symposium on national objectives in space. The coincidence of the successful manned Project Mercury ballistic flight the morning of the same day provided a dramatic background for this symposium.

Section President **Sidney Sternberg** of RCA opened the meeting in the early afternoon, and introduced **Courtland Perkins,** chairman of Princeton's Aeronautical Engineering Dept., who in turn introduced a distinguished panel which would lead the discussion of national objectives. The panel members were **Elmer W. Engstrom,** executive vice-president of RCA, who commented on the role of industry; **Robert Jastrow,** chief of NASA's Theoretical Div., who commented on government's role; **Klaus Knorr** of Princeton Univ., who discussed economics and international implications of space programs; and **Donald Hornig** of Princeton, who discussed the role of the university in relation to the present and future of space programs.

Their comments started a lively exchange with the audience of over 100 persons. The meeting adjourned at 5:15 p.m., but the interchange of comments continued at an informal reception and dinner at the Princeton Inn.

The afternoon proceedings were recorded, and it is hoped that after review and editing they will be made available for wider distribution to the ARS membership, industry, government officials, and other interested groups.

—H. M. Gurin

Sacramento: At the regular monthly meeting in April, Aerojet-General Vice-President **W. L. Rogers** talked to members and guests on "Inner and Outer Space—the Twin Challenges of the Future." He referred, of course, to the quickening pace of exploring and exploiting both the oceans and space beyond the sensible atmosphere. Dr. Rogers related these explorations to the activities of Aerojet-General's Azusa facilities. Azusa has been in the underwater business for 17 years, and Rogers showed slides of its work on underwater transport, torpedoes, and underwater propulsion. Among the extensive and diversified projects of Azusa in space technology, he mentioned the development of a chromatograph by the Chemical Div. for exploring the moon's surface for organic molecules.

In March, the Section reviewed the progress of the Inter-Society Education Council, which it was instrumental in forming. A note on a recent activity of the Council appears at the bottom of page 80.

The evening's speaker was **R. Masterson,** customer relations representative for Aerojet-General's Spacecraft Div. in Azusa, who discussed the growth of the Spacecraft Division. This Aerojet-General group operates from a systems-management approach, and can call on either the Liquid or Solid Rocket Plant for propulsion systems, as required. Involved in the systems approach are such items as guidance, flight control, telemetry, and range safety, besides propulsion. The Spacecraft Div. is also actively investigating communication satellites. The investigation includes not only a satellite, but also launch vehicles and ground-support equipment.

—M. Halebsky

Tennessee: In April, the Section enjoyed an especially fine talk by guest **T. J. Newman,** head of the Systems Research Section of Arma Div., American Bosch Arma Corp., on "Guidance of Space Vehicles." Newman discussed the basic concepts of space-vehicle guidance and the inertial-guidance system in particular. Starting with the basic means of measuring acceleration, he progressed through the method and reasons for the gyro-stabilized reference platform, the integrator equipment to determine velocity and position, and the computer required to translate inputs into final guidance and control. Finally, he compared advantages of radio and inertial guidance.

Upon the kind invitation of the ARS Alabama Section, some 30 members of the Tennessee Section attended a guided tour of some portions of the Redstone Arsenal on April 15. Included in the tour were visits to the Fabrication Lab, where buildup of the

A Space Guidance Guide

T. J. Newman, head of the systems research section of American Bosch Arma's Arma Div., makes a guest appearance before the ARS Tennessee Section to discuss inertial and radio guidance of space vehicles.

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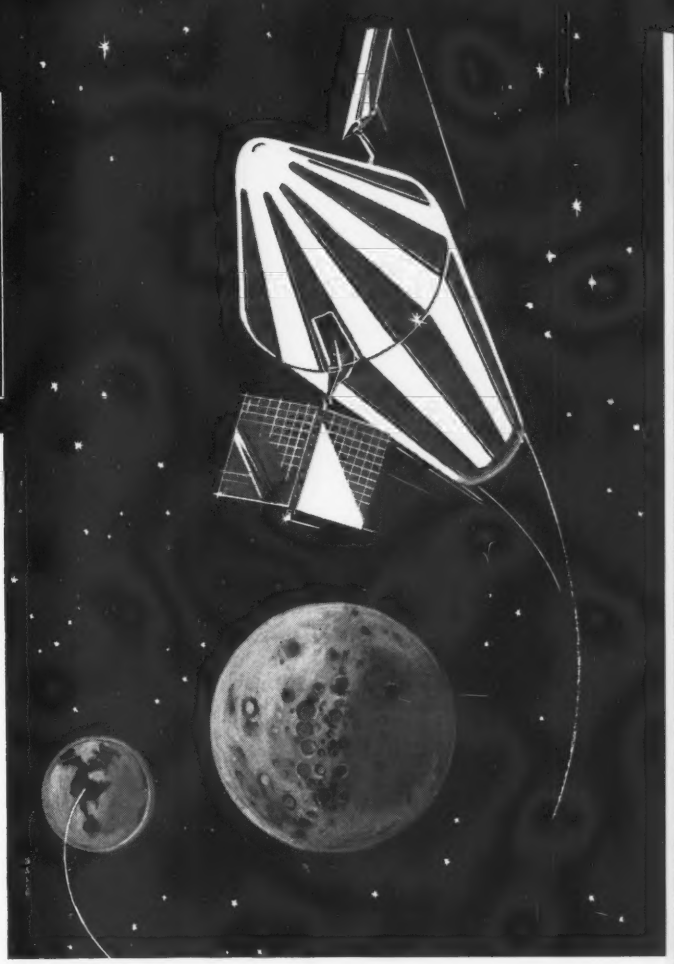

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first flight Saturn was in progress; the static-test tower, where a Saturn booster was installed; and finally an inspection of the barge Palaemon, which will ship the flight vehicle to its launch site at Cape Canaveral. Many thanks to the Alabama Section for their gracious hospitality.

—Thomas J. Gillard

STUDENT CHAPTERS

Florida State Univ.: At the last meeting for this semester, **B. G. MacNabb** of the Convair-Astronautics group at Cocoa Beach, Fla., spoke on "Past, Present, and Future of Our Missile Program," using as illustration models, sketches, and a film on the firing of an Atlas missile. His talk evoked a lively question and answer period.

—Mary Grossenbacher

Northwestern Univ.: In March, our guest **Arthur Kantrowitz,** director of Avco-Everett Research Laboratory and vice-president of Avco Corp., addressed about 60 members and guests of our Chapter and the local Chapter of the American Institute of Physics. The title of his talk was "Relationship of Science to Society."

Dr. Kantrowitz discussed the dangers involved in allowing an oligarchy control of the scientific programs of our society. He also outlined a program by which new research and development could be financed on a "credit rating" system. The more ability a researcher showed, the more credit rating he would establish, and thereby obtain more funds. A lively question period touched on such subjects as our space program, the Russian space program, and the education of the American public. A dinner attended by officers of the societies and members of the faculty honored Dr. Kantrowitz before the lecture.

—Norman R. Trudeau

Univ. of Washington: In April, our guest speaker, **Al Thalheimer** of Minneapolis-Honeywell, discussed inertial guidance. His talk covered the history of inertial guidance, noting, in particular, the problems which arose and the techniques, successful and otherwise, applied in an attempt to solve them. He also discussed the results of reliability studies made on early systems and on present ones, and the tolerances of the two for comparison.

In a May meeting, the Chapter was treated to a fine discussion of manned space flight by **Everett H. Dale,** quality-control manager for Minneapolis-Honeywell's Aeronautical Div. Dale believes that man's function in space will certainly be multi-purpose, and will include doing work automatic machines cannot. Moreover, he sees the role of the astronaut becoming more and more important as flight times grow longer and cut out ground maintenance. Dale outlined these quality and reliability challenges facing the industry: "The development of in-flight equipment monitoring and repair programs which will serve in the same manner as ground-based maintenance; development of reliable lightweight test equipment to allow this approach; improvement in reliability prediction and design-analysis techniques to increase our confidence in them; development of superior means of assessing reliability of basic electronic parts and components on small-run lots; and discovery of the optimum design for reliability with full consideration of expected failure modes."

—Patricia Blake

Beginnings

Wernher von Braun presents an ARS charter for the new Kansas State College at Pittsburgh Student Chapter to its first president, Eldon Offenbacher, in ceremonies at the annual banquet of the Joplin, Mo., Chamber of Commerce. Other K.S.C. of Pittsburgh officers include Paul E. Grayson, vice-president; Jerry P. Coburn, secretary; and James K. Newcomer, treasurer. Professor George H. Mycroft sponsors the Chapter.

Three Companies Become ARS Corporate Members

Three more companies have joined ARS as corporate members and will participate in Society activities. The companies, their areas of activity, and those named to represent them are as follows:

ASTRA, Inc., Raleigh, N.C., is engaged in nuclear propulsion, medical engineering, radiation environments and shielding, environmental instrumentation, engineering analyses and computer programming, and cryogenic magnets. Named to represent the company are J. Frank Coneybear, president; Henry R. Kroeger, vice-president and manager, nuclear propulsion; Richard C. Pinkerton, manager, chemical research; Daniel I. Weinberg, manager, medical engineering; and Richard G. Mallon, project engineer, cryogenic magnet applications and consultant.

E. I. du Pont de Nemours & Co., Wilmington, Del., is involved in research, development, and production of propellants and chemical intermediates, including polymerics. Representing the company are R. M. Cavanaugh, director, R&D Div., Explosives Dept.; E. D. Champney Jr., assistant marketing manager, Sales Div., Polychemicals Dept.; Elbert V. Kring, research chemist, Electrochemicals Dept.; Fred S. Palmer, technical associate, Organic Chemicals Dept.; and Henry F. Peters, marketing manager, metal products, Pigments Dept.

Taber Instruments Corp., North Tonawanda, N.Y., does its own research and delvelopment and manufacture of aerospace electronics and aerospace medical equipment. Representing the company are R. F. Taber, chief engineer, J. E. Raab, manager, Electronics Div.; W. Greatbatch, manager, Aerospace Div.; R. H. Halverson, West Coast service engineer; and William Hessinger, aerospace quality control engineer.

Sacramento Section Awards Astronautics Trophy

The ARS Sacramento Section presented its annual high school award this year to co-winners Dennis Roby of Folsom High School and Gary Withrow of Bishop Armstrong High School in California. Each co-winner will receive a $50 cash award and an individually inscribed trophy. In addition, each high school will receive a larger, circulating trophy which will become the possession of the school after there have been three winners from it.

The objectives of this science-award program are to popularize and publicize rocketry, particularly among high school students, to grant a measure of recognition to academically qualified students interested in astronautics, and to encourage students to continue an education in astronautics. ♦♦

Venus Revealed

One of the highlights of space research this spring was the two-month Venus radar bounce experiment conducted by NASA's Jet Propulsion Laboratory. This experiment produced a new, more-exact value for the Astronomical Unit (AU) of 92,956,000 statute miles, plus or minus 1000 mi. The experiment also produced data which indicate Venus rotates at an extremely slow rate, as had been suggested by Gerard Kuiper—perhaps as slow as once per 225 days, the length of the Venusian year as it rotates around the sun.

The results were announced by Walter K. Victor and Robertson Stevens, co-directors of the experiment. They have said that refinement of data should reduce the uncertainty of the AU to plus or minus 100 mi. by this month.

In the experiment, JPL's Goldstone Deep Space Instrumentation Facility (DSIF), 50 mi. north of Barstow in California's Mohave Desert, made radio contact with Venus at 2388 mc/sec daily from March 10 through May 10. The Goldstone receiver used both a cryogenic ruby maser and parametric amplifier. The experiment was thus similar to the one conducted by Lincoln Labs on Feb. 10, 1958, and reported a little over a year later (see the May 1959 *Astronautics*, page 50).

A radio signal aimed at a perfectly conducting sphere should give 100% signal return as an echo. Using this as a standard of conductivity, the radio returns from Venus indicate that it has a reflectivity of 12%. This number is similar to the value of the reflectivity of the earth. Similar experiments on the moon show the lunar surface has a much lower reflectivity—about 2%.

Polarization studies of the radar returns at Goldstone further indicate that Venus scatters the Goldstone signal at 2388 mc/sec much as the moon does, which indicates that Venus has a roughness similar to that of the lunar surface.

Eberhardt Rechtin, DSIF director, says data from the experiment will greatly aid NASA-JPL's program to send instrumented spacecraft to Venus and other planets. "Up until now," he commented, "we have not known the position of the planets to any great accuracy because of the uncertainty in the AU. Clearly this lack of knowledge of the position of any planet at any time would increase the engineering difficulty in an attempt to impact Venus or Mars or to place a spacecraft in orbit around on of the planets.

"Another uncertainty, the unknown reflection properties of the surface of Venus, previously made design of spacecraft radars almost impossible. This uncertainty now has been removed. A determination of the slow rotation rate of Venus also reduces the uncertainty of landing on the surface."

More will be heard of this experiment. W. K. Victor comments that the final results depend on calculation of the orientation of the spin axis of Venus—a difficult affair for such a slowly rotating body.

Assignment: manufacture star-shaped flame shields, heat shields, and other important structures for NASA's Saturn booster. That's only one side of the Lockheed/Georgia aerospace story. We offer space-oriented research (cryogenic lab, hypersonic shock tunnel, human factors). We know how to build huge structures. And we're at the hub of the Strategic Southeast—practically next door to Huntsville and Cape Canaveral. **LOCKHEED/GEORGIA**

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Spacial relationships in the JPL Venus radar bounce experiment conducted from March 10 to April 10.

Communication Satellites

(CONTINUED FROM PAGE 45)

as a function of the altitude of apogee.

Elliptic orbits, however, have three disadvantages. To maintain a constant signal-to-noise ratio from the satellite, it is necessary to vary the antenna gain in elliptical orbits. The perigee altitude for usable elliptical orbits will cause the satellite to pass through the high-energy radiation of the inner Van Allen belts. Moreover, if perigee falls below 200 mi., atmospheric drag will cause an unstable ephemeris. We conclude that, except in special cases, the circular orbits are preferable.

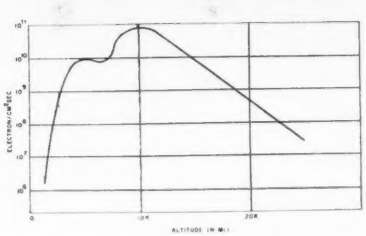
To minimize the system complexity required for multiple-bounce relay, the satellite should be above some minimum altitude. As an example, if you want to transmit from the west coast of the United States to Japan, a satellite at the midpoint of the great-circle arc connecting these two areas must be at an altitude of at least 900 mi., even to be within line of sight of both ground stations. To maintain contact with both San Francisco and Tokyo for an arc of 30 deg in longitude, an equatorial satellite must be at an altitude of more than 7000 mi. Furthermore, it can be shown that for continuous San Francisco-Tokyo communication no fewer than five equatorial or six polar satellites are required for any altitude, even at infinity, with the single exception of the 24-hr equatorial satellite, in which case only one is required. The graph on page 44 plots the number of satellites needed in circular polar orbits to achieve 100% coverage of three pairs of cities.

Weight Saving

These curves assume that the satellites in orbit are controlled both in initial placement in orbit and maintenance of that place during the satellite lifetime. Alternately, at a savings of the weight of the "station-keeping" system in the satellite, the satellites can be launched into a specified circular orbit without attempting to control their relative positions in that orbit. To be assured of mutual visibility of one satellite between two ground sites, a significantly greater number of satellites randomly placed in an orbit needs to be launched, again, however, depending sharply on altitude if it is below 5000 mi.

As the graph on page 45 shows, 99% coverage between New York and Paris requires 100 satellites randomly located in a circular polar orbit at an altitude of 2000 mi., but requires only 25 satellites at 5000 mi. To achieve the same coverage between Tokyo and

Electron Intensity Above 20 Kev



Portland, Ore., requires a larger number of satellites; and, in fact, random placing of the number of satellites in orbit to assure communication between these two cities is at the same time almost equivalent to achieving global coverage.

With omnidirectional antennas on an active repeater satellite, it is probably not possible to go above altitudes of 4000 mi. and maintain a minimum-quality television circuit. Thus, if an omnidirectional antenna is to be used, the satellite must be lower than this altitude, and preferably it should be no higher than 2000 mi. Once this altitude is exceeded, it is necessary to introduce an attitude-control system on the satellite to permit the aiming of directional antennas toward the earth.

With attitude control, some of the other subsystems of the satellite are either simplified or reduced in weight. If a solar-cell power supply system is to be used, as appears necessary, the cells can be kept oriented toward the sun, with a resultant major reduction in number and weight. The problem of temperature control is simplified by attitude control since the fact that some surfaces will always face the sun and some will never face the sun can be utilized to effect efficient control of heat radiation from the satellite. In addition, once attitude control permits directional antennas facing the earth, then for any given area of the surface of the earth the signal-to-noise ratio required is independent of altitude; as altitude increases, a more directive antenna permits illumination of the same area on the earth.

There is therefore a critical altitude at about 5000 mi., below which it is possible to use omnidirectional antennas and relatively simple satellites and above which directional antennas and attitude control are desirable. At the same time, however, there is a sharp decrease in the number of satellites required for altitudes above 5000 mi.

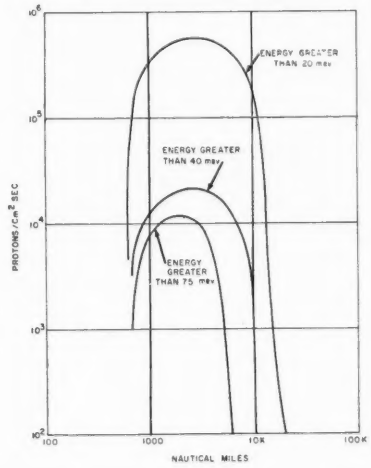
An important consideration in the choice of satellite altitude is the time delay involved in the round trip over the communication link. Studies of the effect of time delay on telephone conversation are now in progress.[1] It is possible that the 0.6-sec round-trip delay which is introduced by a satellite relay at the distance required for a 24-hr orbit will make that altitude undesirable for commercial telephone relaying unless special send-receive techniques are devised. On the other hand, this time lapse will not impair one-way communications or affect military requirements. In fact, the delay may be useful to military communications by simplifying anti-jamming techniques.

A further consideration in the choice of altitude for a communication satellite is the effect of space environment. Of the many known characteristics of the space environment, seven can have bad effects: The hard vacuum, micrometeorites, ultraviolet radiation, X-rays, gamma rays, trapped electrons, and trapped protons. Of these, the last four relate significantly to altitude. The effects of magnetic fields, infrared radiation, cosmic rays, neutrons, alpha particles, and higher-atomic-number particles can be ignored because of their negligible effect or occurrence.[2]

Radiation Damage

Energy in the X-ray region (1 to 100 Å) and the gamma-ray region (0.1 to 1 Å) of the solar spectrum is negligible except during intense solar flares, and the cumulative effect of these flares is not sufficient to cause significant damage to a satellite. The bremstrahlung effect—in which some of the energy of particle radiation interacting with a material is re-radiated as X-rays and gamma rays—can be a factor, however, in damage to satellite materials. Although the energy levels of this secondary radiation are always considerably below the primary, the fact that bremstrahlung radiation is highly penetrating makes shielding

Proton Intensity at The Geomagnetic Equator



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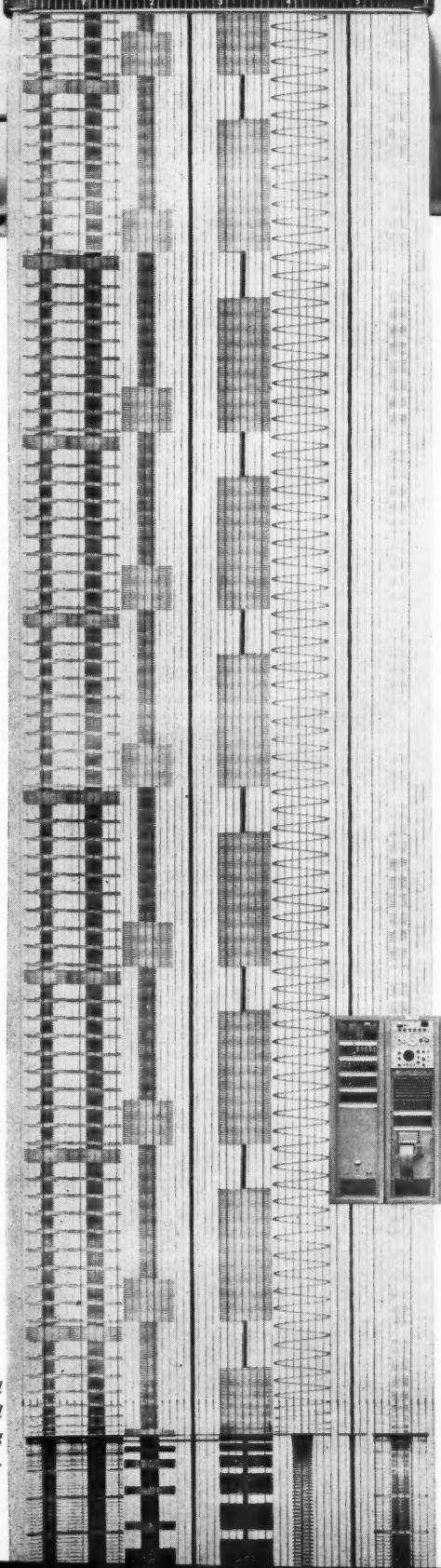

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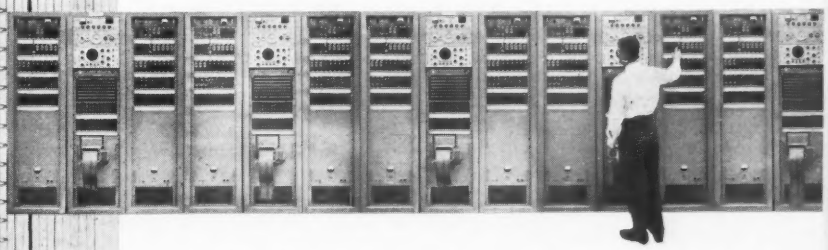

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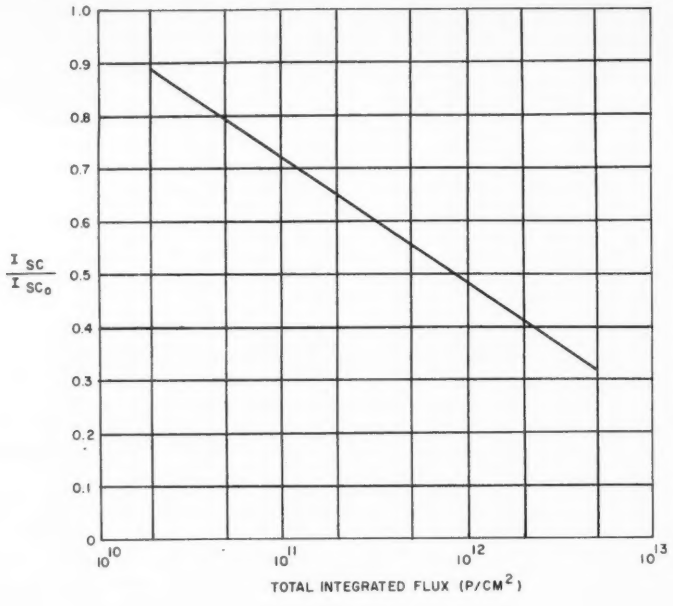


difficult, and the effects on semiconductor devices and organic material used in insulation can reduce their operational effectiveness sharply as a function of time. Elimination of the hazards from primary radiation, however, will at the same time eliminate the possibility of damage from X-rays and gamma rays.

Ionization Not Significant

The primary cosmic flux consists of particles with energies ranging from a few mev to 10^9 bev, with 80% of the flux made up of protons. Maximum cosmic ray intensity—about 2 particles/cm^2 sec—is reached at altitudes greater than 15,000 mi. over the equator and greater than 10,000 mi. over the poles. Maximum ionization in any material due to cosmic rays is 1 milliroentgen per hour, and does not appear to be a significant factor in affecting satellite operation.

A reasonably complete map of the ionizing radiation trapped by the geomagnetic field has been provided by Explorer VI. From these data and previous measurements it is clear that there are two distinct belts of trapped radiation—the inner belt, containing largely high-energy protons, and the outer belt, containing largely low-energy electrons. The graphs on page 82 show the quantity of electrons and protons in these zones as given by recent measurements.

The principal damage from particle radiation occurs as ionization and atom displacement in the effected material, with resultant permanent changes in electrical conductivity and physical characteristics. The low energies of the electrons encountered anywhere in space permit effective shielding with very little addition of weight, but the shielding required by the high-energy protons in the inner radiation belt is prohibitive. As the graph on page 82 shows, the incident proton radiation of 20 to 75 mev can reach counts of 10^4 to 10^6 per cm sq per sec at altitudes of 1000 to 10,000 n.mi. The highest energy protons—values 700 mev and above—are found at altitudes of 2000 to 4000 mi. The damage that this radiation can produce is illustrated by the graph above here, which compares the short-circuit current of silicon solar cells before and after exposure to 740-mev proton radiation.[3] An integrated flux of only 7.5×10^{10} p/cm^2 at 740 mev produces a 25% decrease in solar-cell output, and 10^{12} p/cm^2 reduces the output 50%.

Thick Shielding Required

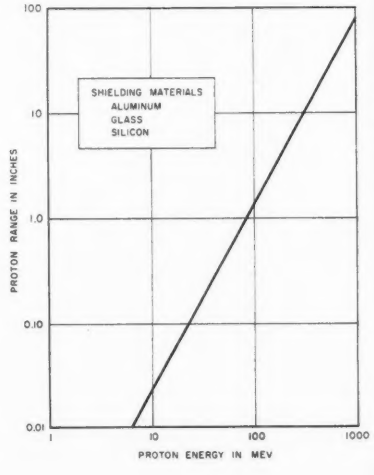
Radiation damage can be prevented by the use of adequate shielding. The graph at right shows shielding required to protect against high-energy protons. As can be seen, preventing damage from protons encountered in the inner radiation zone requires at least a 10-in. thickness of the shielding material most effective against protons. From this it appears that the only effective deterrent to significant proton damage of communication satellites is to place the satellites at altitudes below or above the inner belt. This would place the satellite below approximately 1000- or above 10,000-mi. altitude.

To summarize, we have seen that at an altitude of approximately 5000 mi. there is a relatively sharp demarcation in the requirements imposed on the system complexity of a communications satellite on the one hand and on the number of satellites needed for useful coverage on the other. In the region below 5000 mi., an active communications satellite cannot long survive unless it is below an altitude of approximately 1000 mi., in which case omnidirectional antennas and relatively simple subsystems would provide adequate service.

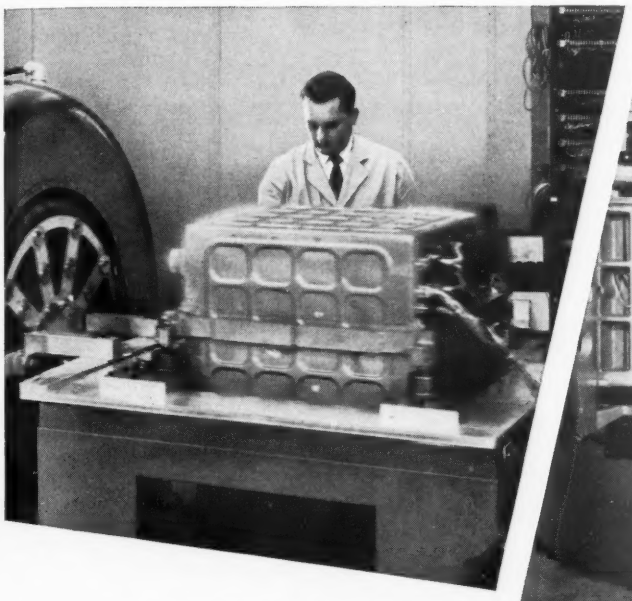
Since, for intercontinental visibility, the lowest useful altitude is approximately 2000 mi., we conclude that low-altitude active repeaters using solid-state electronics are not feasible. In any case, circular orbits of 1000 or 2000 mi. will require on the order of hundreds of satellites to provide significant coverage, and many launches would be required each year to sustain the system.

To bring about significant reduction in the number of satellites launched, we need to go above altitudes of 5000 mi. Here, to assure high-quality communications, we need to use active-repeater satellites. Once we have chosen active satellites, the space environment forces us to a minimum altitude of 10,000 mi. Since at such altitudes it does not significantly affect launch or satellite complexity or cost to go higher, there is every advantage in choosing the altitude and orbit requiring the least number of satellites, whether we desire a specific point-to-point coverage or global capacity. The circular equatorial orbit at an al-

Shielding Thickness Required Against High-Energy Protons



ARMA SYSTEMS



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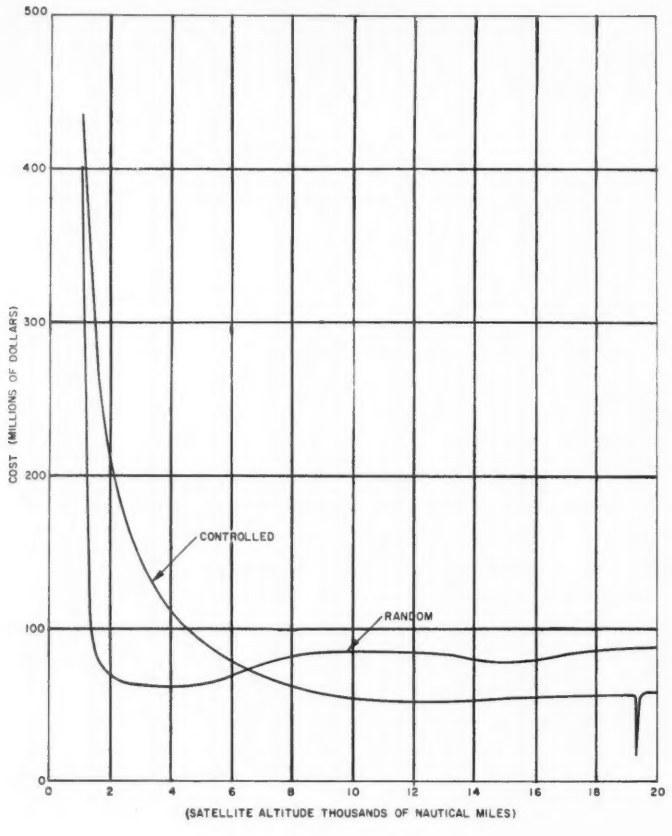
Cost of Establishing Communications Satellites for Continuous Coverage, New York to Paris



titude of 19,323 n.mi., unique in its minimum of one satellite for point-to-point coverage for almost any pair of major cities in a hemisphere, is a logical choice. If time delay is a real problem for voice communications, then an orbit with a 12-hr period would appear to be the most desirable.

In establishing and maintaining a communications satellite system, the major costs will be distributed among three elements—the satellites themselves, the launches, and the ground station. The costs of these elements will depend, of course, on the quantity and complexity of each. The satellite cost will be minimum for small, passive reflectors and maximum for active repeaters with directional antennas and attitude controls. The launch cost will vary. It will be low for relatively small rockets and simple launch procedures to place passive satellites in low-altitude orbits. It will be high for the large boosters and more complicated procedures needed to place active repeaters at high altitudes. The power requirements and antenna sizes for the ground stations will increase with the satellite altitude, but at the same time the angular tracking rate of the ground antenna will decrease as the altitude of the satellite increases.

Combining the cost of the satellite, booster rockets, and launch procedures into an approximate cost per launch provides a range of $500,000 to $5,000,000 for repeater satellites which do not maintain themselves in position in orbit, the cost increasing with the altitude of the satellites.[4] Similar approximations provide a range of $5 million to $9 million per launch for satellites in controlled orbits. The cost of each ground station is estimated at $2.5 million, regardless of satellite altitude.

Conservative estimates indicate that it is reasonable to expect a mean time to failure of an active-repeater satellite of 1.5 years and a successful launch probability of 0.75 by late 1963. The cost of establishing a communications satellite system can be approximated by the formula $C_E = C_g N_g + (N_s/pn)(C_B + nC_s)$. The expected annual replacement cost is given by $C_M = (N_s/pnt)(C_B + nC_s)$

where N_g = the number of ground stations

N_s = the number of operating satellites required in the orbital set

p = probability of a successful launch

t = average lifetime of a satellite

n = number of satellites launched per booster

C_g = cost of each ground station

C_B = cost of booster, launching operation, and range time

C_s = cost of satellite vehicle

The cost estimates obtained by these means are useful principally for comparing systems and not for careful estimates of the design of a given system, since such factors as amortization of development costs and maintenance of an adequate inventory of spare equipment are not included.

Costs for establishing and maintaining a communication satellite system for a New York-Paris point-to-point trunk line system and for global coverage have been calculated both for randomly located and controlled satellites. The graph at top left shows that, above 6000- and 7000-mi. altitude, it is less expensive to establish and maintain coverage between New York and Paris by means of controlled satellites, despite the increased cost of the individual satellites and launches. Moreover, the cost at the 19,323-n.mi. altitude is uniquely minimum. Coverage can be obtained at this altitude by only one satellite (thus an allowance of two launches to establish the satellite in orbit). At approximately $9 million per launch, then, the system can be established for $18 million, together with the $5 million for the two ground stations—a total of $23 million. The same rationale applies to the cost of maintaining the system, which would require an annual expenditure of $8 million, using a figure of 0.9 launch per year for satellite replacement.

Cost Varies with Altitude

For global coverage, the cost of establishing ground stations becomes a factor which also will vary with satellite altitude, since more stations will be needed to assure point-to-point communications throughout the world when satellites are in lower orbits, as indicated in the graph on page 88. The minimum cost for establishing global coverage with satellites randomly located in orbit will occur when

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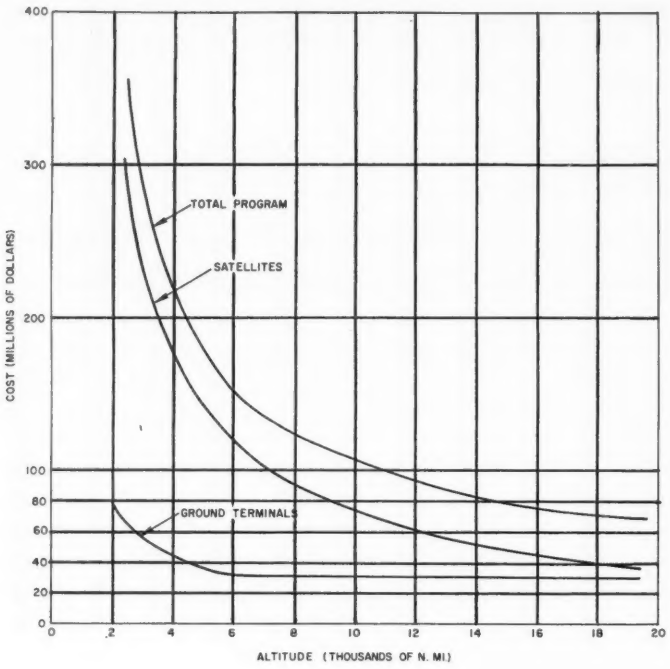
Estimated Costs for Establishing Global Coverage with Repeater Satellites in Controlled Orbits



circular polar orbits of about 6000-mi. altitude are used, including a cost of approximately $32 million for ground stations and $93 million for satellites. The minimum for controlled satellites occurs again at the 24-hr synchronous altitude, an estimated total of $70 million, including the four launches probably being required to place three satellites in synchronous orbit. An annual maintenance cost of $18 million to cover 1.96 launches is required for this system.

If we eliminate all orbits below 10,000 mi., we have in effect eliminated all but three, namely: (1) 12-hr circular polar orbit, (2) 12-hr circular equatorial orbit, and (3) 24-hr equatorial orbit.

On the basis of cost alone we could eliminate the 12-hr orbit sets and conclude that the optimum would be the 24-hr equatorial system. However, the two-way signal time delay in the 24-hr system may preclude its use for commercial telephone circuits. Whether this delay will constitute a serious problem for two-way voice communication is yet to be resolved. A limited number of tests have been made which simulate both the delay

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and the lockout occasioned by the action of echo suppressors. Unfortunately, various studies have given conflicting results, and so we do not have sufficient criteria for deciding between a 12-hr polar set and a 24-hr equatorial set. The former may be between two or three times more expensive to maintain than the latter, but a carrier may be pleased to pay the price.

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Von Karman at 80

(CONTINUED FROM PAGE 48)

of which von Karman was the first director (1938–1945). Dr. Pickering announced at the banquet that ARS has established an Annual Von Karman Lecture series, carrying a $1000 honorarium, with the first lecture to be delivered next year.

Hale and hearty at 80, von Karman is still as active as ever. At the moment, for example, he is chairman of the NATO Advisory Group for Aeronautical Research and Development, a post he has held since 1952; chief consultant and chairman of the Technical Advisory Board of Aerojet-General, which he helped found in 1942 as Aerojet Engineering Corp.; scientific director and honorary Board Chairman, General Applied Science Laboratories; chairman of the Board of Direction of the Training Center for Experimental Aerodynamics in Belgium; Director of the International Academy of Astronautics; and Editor-in-Chief of *Astronautica Acta*.

The day-long affair was carried out under the direction of IAS under an AFOSR contract. ♦♦

Redstone Arsenal Renamed

The part of the Army Ordnance Missile Command called Redstone Arsenal has been renamed the Army Ordnance Missile Support Agency. Redstone Arsenal remains the name of the 40,000-acre Army reservation at Huntsville, Ala., and the mailing address and base for the newly named agency, AOMC headquarters, ABMA, ARGMA, and AOGMS.

In the Mercury Project, as in program after program, Ordnance Associates Pyrotechnic and Explosive Devices are chosen for critical assignments demanding proven reliability.

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Design notes

Uncooled Nozzles for Attitude Control

By Walter F. Keller, Research Engineer

M-H MISSILES DEVELOPMENT LABORATORY, LOS ANGELES, CALIF.

In attitude-control systems, high-energy hypergolic liquid propellants can provide a considerable gain in performance over liquid monopropellants or solid-propellant gas generators. This is particularly true of the on-off, or limit-cycling, control system, in which pairs of opposing jets are intermittently pulsed to maintain vehicle attitude between desired limits. Firing pulse widths are usually very small—on the order of 0.2 sec or less. When there are no external disturbances, the duty cycle (or pulse rate) can be very low, if the jet response is rapid. Duty cycles may be high during control of booster rockets, due to thrust-misalignment forces, but the control period is usually brief.

The disadvantage of intermittent, high-speed operation is that it precludes regenerative cooling of the reaction jet. An analytical study was made to determine the extent to which this could be turned to an advantage in extending the life of an uncooled unit.

With the aid of an analog computer a transient-heat-transfer analysis was made of a design which provided only insulation and heat storage. Radiation through the walls was not permitted, since controls are often mounted in regions where this could be harmful. Radiation from the inner face of the nozzle to space will occur, but will be small and was omitted from the calculations. Since the heating problem is primarily in the rocket throat, an insert type of design, such as shown on the graph here, was studied.

The analysis had two goals: To determine good design criteria, and to study performance of a good design. Results were based on a combustion gas film temperature of 5100 F and use of ordinary one-dimensional heat-flow equations. The following essential design criteria were established:

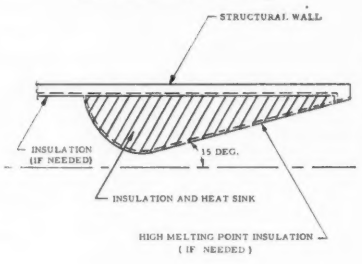
- The body of the insert must serve as sufficient conductor and heat sink to prevent the inner surface (flame side) from reaching its melting temperature, and must provide sufficient insulation to prevent the outer structural wall from reaching its failure temperature.
- Materials: Graphite, tungsten, or the cermets are suitable insert materials. Zirconia is useful both as flame insulation and oxidation protection. Stainless steel is sufficient for the wall.
- Operation at low chamber pressures greatly reduces heat transfer to the walls.

Performance of a typical design of stainless steel, graphite, and zirconia, operating at a chamber pressure of 150 psi, was studied with results as plotted in the graph here. The effect of pulse width was found to be negligible in the range 0.05 to 0.4 sec. Hence, the curves are based on 0.2 sec.

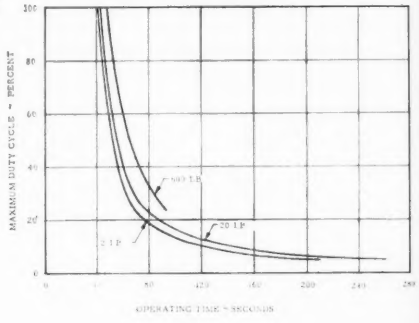
The indicated realm of jet operation appears suitable for application on ballistic missiles, space probes, and orbiting vehicles. Operating duration at high duty cycles is long enough to serve during missile boost.

Although the effect of radiation cooling has not been taken into account in this analysis, it should be sufficient to permit indefinitely long operation at low duty cycles. Reaction-jet weights will be similar to comparable monopropellant units; the weight of nozzle-insert material will be no more than equal to the monopropellant catalyst beds. High time response (through buildup and cutoff) is essential to low operating duty cycles. This response can be obtained with hypergolic propellants by eliminating regenerative-cooling passages and mounting quick-acting valves adjacent to the thrust chamber.

Nozzle-Insert Design



Maximum Duty Cycle Vs. Operating Time



Torque-Measurement Fixture for Dyne-cm Range

By Samuel J. Bond, Principal Engineer

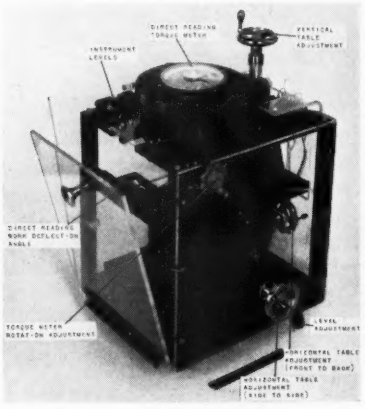
FORD INSTRUMENT CO., LONG ISLAND CITY, N. Y.

An instrument has been developed for measuring low dyne-cm torques, such as the reaction produced by a gyro electromagnetic pickoff or the output of a torque unit used for precessing a gyro. This instrument is easier to use, and more accurate in its range, than present optical equipment employing an air bearing. It provides a method of measuring reaction torque of various pickoffs by a direct-reading, fast, easy procedure.

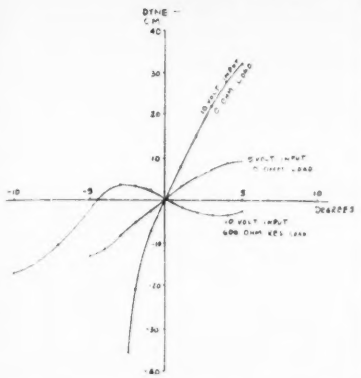
Test results have been checked against measurements taken using an air bearing and autocollimator setup. There is good agreement. The torque-measurement fixture can measure in 1 hr characteristics which require two days using the air bearing-autocollimator setup. The instrument thus opens the way for many new semi-empirical development and application programs.

A preliminary investigation of a commercial d'Arsonval type meter indicated that the instrument's torsion springs were capable of exerting a counter torque of 0–50 dyne-cm as the meter's moving coil and pointer assembly were rotated through full scale. By adding a balanced extension to the instrument shaft to enable coupling to the moving element of a pickoff under test, it was reasoned that the reaction torque could be transmitted to the instrument for measurement. Thus the position of the meter pointer on its

Torque Measurement Fixture


DIRECT READING TORQUE METER
VERTICAL TABLE ADJUSTMENT
INSTRUMENT LEVELS
DIRECT READING WORK DEFLECTION ANGLE
TORQUE METER ROTATION ADJUSTMENT
LEVEL ADJUSTMENT
HORIZONTAL TABLE ADJUSTMENT (FRONT TO BACK)
HORIZONTAL TABLE ADJUSTMENT (SIDE TO SIDE)

Reaction Torque Vs. Angle



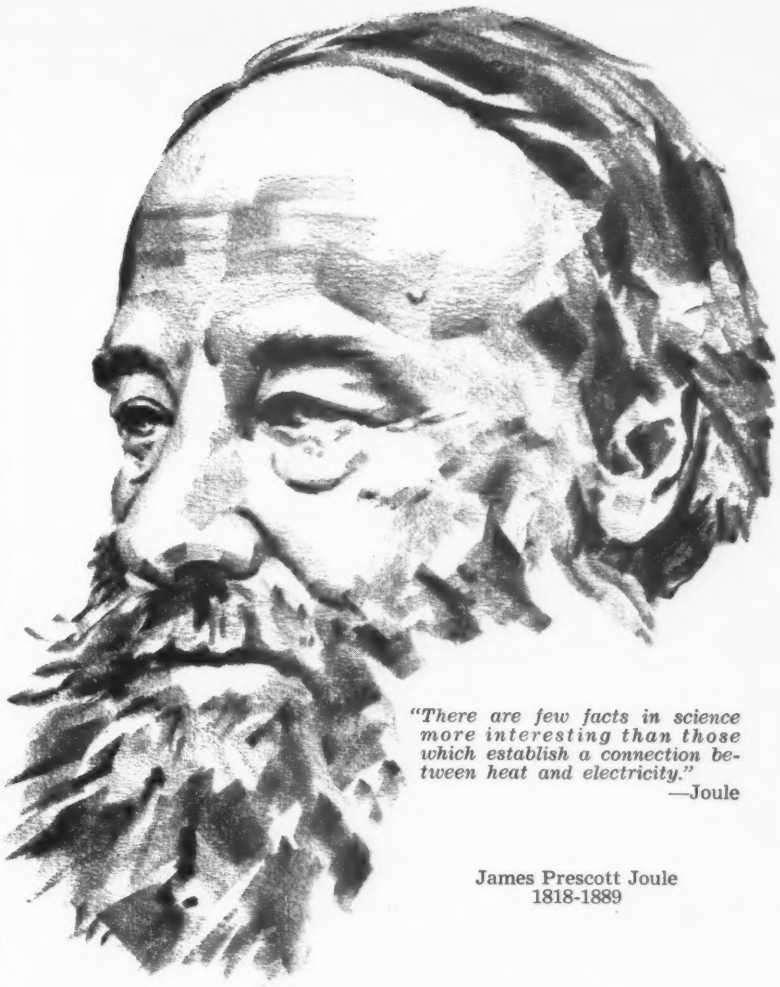
scale would correspond to a value of torque based upon the calibration of the meter torsion springs. In this way torque can be read directly on a meter face.

By allowing manual rotation of the meter case a counter torque could be applied to the pickoff's moving element to hold it stabilized at its zero, or null, position with respect to its stationary field assembly. In this manner, the reaction torque at the null point, which is of primary interest, would be indicated on the meter dial by the pointer. The rotatable meter case also allows adjustment of angle of deflection of the pickoff's shorted turn.

The graph here indicates the type of measurements made on the completed fixture. Marked increments on the faceplate are 4 dyne-cm; readings can be made to ±0.4 dyne-cm. The total meterable torque range in the unit built is 0 ± 100 dyne-cm. Higher ranges, such as 1000 ± 100 dyne-cm, are available through the application of fixed increments of electrical biasing torque of the meter movement. Angular range is 0 ± 15 deg.

Bubblegummer's Dream

Echo II rests fully inflated. The 135-ft-diam, 500-lb balloon satellite, being developed by the G. T. Schjeldahl Co. for NASA, is scheduled to be launched next year. Fifty times as rigid as the 136-lb Echo I, it is expected to retain a spherical shape in space for a long time. Construction involves 0.14-mil laminated aluminum foil (Alcoa) on either side of 0.35-mil Mylar.



"There are few facts in science more interesting than those which establish a connection between heat and electricity."
—Joule

James Prescott Joule
1818-1889

The facts that fascinated J. P. Joule in the nineteenth century are vital at Los Alamos in the twentieth—freshly combined with facts he never dreamed of. Heat from the Omega West Reactor, directly converted by the plasma thermocouple, drives electric motors. Electricity from the Zeus capacitor bank produces thermonuclear temperatures, partly by the familiar process called joule heating. The Los Alamos Scientific Laboratory is proud to acknowledge its debt to great men who have found facts "interesting."

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ASTRONAUTICS Data Sheet — *Materials*

Compiled by C. P. King, *Materials and Process Section. The Marquardt Corp., Van Nuys, Calif.*

WROUGHT NICKEL ALLOYS

These materials are widely used in the non-heat-treated condition, although two alloys, Inconel X and Hastelloy C, are capable of responding to an aging heat treatment. All have excellent corrosion resistance, good tensile, creep, and rupture strength, good fabricability, and good oxidation resistance at over 2000 F.

Fabrication

These alloys have good cold-formability in the solution-treated condition. However, all have a tendency to work-harden, and intermediate solution treatments may be necessary. All the conventional sheet-forming techniques are used. Also, the forging process is applicable to this group of alloys, and some impact extrusion has been done. The solution-treated condition is preferable for machining, but machineability characteristics are inferior to those of steel.

Welding

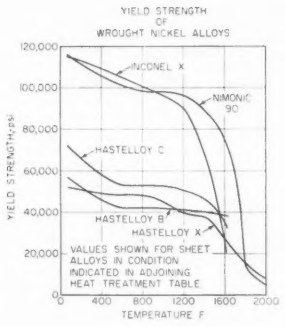
The tungsten arc (inert-gas-shielded) method is used for fusion welding these materials, which should be in the solution-treated condition. Resistance welding and brazing are also used to some extent.

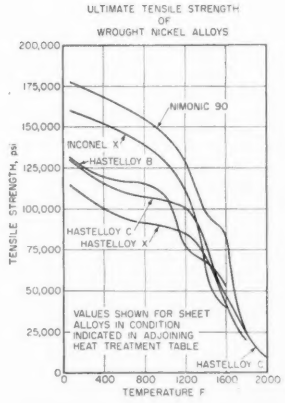
Availability

All of these alloys are available as sheet, plate, bar, wire, and forging stock. Inconel X, Hastelloy B, and Hastelloy C are also available as tubing.

Applications

The gas-turbine industry has made extensive use of these alloys. Components fabricated include jet-engine tailpipes, afterburner parts, turbine blades, nozzle vanes, bolts, and pressure vessels. Inconel X is one of the highest-temperature spring materials available.





Heat Treatment of Wrought Nickel Alloys

Inconel X	1. Solution-treat at 2100-2125 F, air cool, age at 1275-1325 F for 20 hr. 2. For high-temperature applications: Solution-treat then age at 1525-1575 F for 24 hr, rapid air-cool, then age at 1275-1325 F for 20 hr. 3. For spring temper: Solution-treat then age at 1175-1225 F for 4 hr.
Hastelloy C	Solution-treat at 2200-2250 F, rapid air-cool, or water-quench.
Hastelloy B, X	Solution-treat at 2150 F, rapid air-cool, or water-quench.
Nimonic 90	Solution-treat at 1975 F, air cool, age at 1275-1325 F for 16 hr.

Physical Properties of Wrought Nickel Alloys

Alloy	Density, lb/cu in.	Coefficient of Thermal Expansion, micro-in./in./F						Thermal Conductivity, Btu-in./sq ft/hr/F				
Temp, F		70-200	70-600	70-800	70-1000	70-1200	70-1500	392	572	752	932	1112
Inconel X	0.298	7.10	7.91	8.10	8.32	8.46	8.95	94	108	115	128	133
Hastelloy B	0.334	5.60	6.41	6.57	6.66	6.73	6.96	85	91	98	106	114
Hastelloy C	0.323	6.30	7.02	7.35	7.44	7.73	8.07	78	88	98	108	118
Hastelloy X	0.297	7.70	7.90	8.15	8.39	8.56	8.92	89	99	113	133	144
Nimonic 90	0.299	6.40	7.10	7.40	7.70	8.40	8.90	80	91	98	110	128

Chemical Composition of Wrought Nickel Alloys

Alloy	C	Mn	Si	Fe	Cr	Co	Mo	V	Ti	Cu	Al	W	Cb
Inconel X	0.08 max.	1.00 max.	0.5 max.	5.0–9.0	14.0–17.0	1.0 max.	—	—	2.0–2.75	0.5 max.	0.4–1.0	—	0.7–1.2
Hastelloy B	0.05 max.	1.00 max.	1.00 max.	4.0–7.0	1.00 max.	2.50 max.	26.00–30.00	0.20–0.60	—	—	—	—	—
Hastelloy C	0.08 max.	1.00 max.	1.00 max.	4.0–7.0	14.50–16.50	2.50 max.	15.00–17.00	0.35 max.	—	—	—	—	—
Hastelloy X	0.05–0.10	1.00 max.	1.00 max.	17.0–20.0	20.50–23.00	0.5–2.5	8.00–10.00	—	—	—	—	0.2–1.0	—
Nimonic 90* (Nominal)	0.06	0.5	0.3	0.47	20	16	—	—	2.5	—	1.3	—	—

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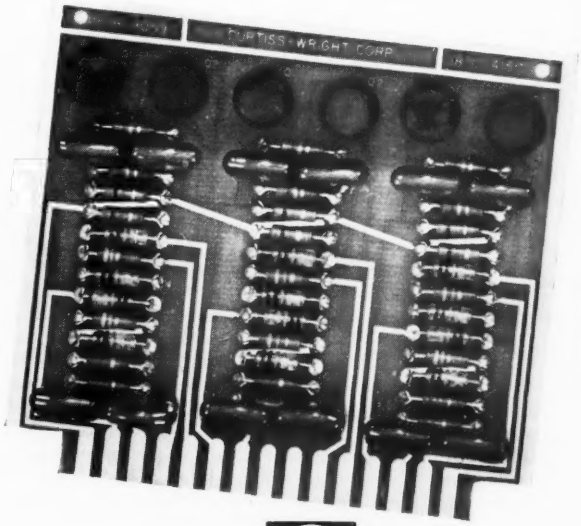

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Nuclear Rockets

(CONTINUED FROM PAGE 25)

would probably have three stages propelled by engines having nuclear reactor thermal powers in the range from 1000 to 10,000 megawatts. It would still have to be assembled in the earth orbit. Two to four launch vehicles or launch freighters would be required to place in orbit all of the material, equipment, propellant, etc. that would be required for assembling the spacecraft. It is important to recognize that the launch freighters could be the vehicles that would perform the manned lunar-landing mission. In addition, the reactor power required for the planetary trip are in a range that could be used in vehicles for lunar-landing operations. The technology required for planetary missions would provide much of the equipment required for the performance of extensive lunar operations.

As noted above, it is generally agreed that the performance of planetary manned missions will require the use of nuclear energy systems. From a practical point of view, chemical systems could not do that job. Even if they could, analyses indicate that the cost saving of the nuclear rocket over the chemical rocket system, including the development costs, appear to be so great that the nuclear rocket would pay for itself on its first planetary mission.

In order to indicate how the required technology for the planetary mission could provide much of the equipment that would be required in extensive manned lunar operations, let's turn our attention now to some of the approaches that have been considered for landing men on the moon and the requirements of the various possible approaches. In defining the lunar-landing vehicle systems, we must first specify the payloads that are required to perform the mission. At the present time, estimates vary between 8000 and 15,000 lb as the weight of the manned capsule that must be returned to the earth after accomplishing the lunar-landing mission. In this discussion, let's consider vehicle systems that can return the high value, 15,000 lb, because I believe that, for a change, we ought not to restrict ourselves to marginal systems. We should have sufficient payload capability to insure ample margin for the inevitable increases in weight requirements that will result.

The Saturn vehicle now being developed is inadequate to provide such a capability unless several (more than six) are used to rendezvous in earth orbit and fuel or assemble the lunar chemical-combustion spacecraft. Although the development of orbital rendezvous is essential to our long-term space program (I indicated earlier that the planetary spacecraft will have to be assembled in an earth orbit), the rendezvous of such a large number of vehicles may not be practical within this decade.

The use of nuclear propulsion systems can reduce the number of Saturns required to rendezvous in orbit. A nuclear system can be used to propel the spacecraft assembled in orbit or a nuclear stage can be used as a third stage of the Saturn vehicle. The application of such nuclear stages could reduce the number of Saturn vehicles required to assemble or fuel the lunar spacecraft. The orbital payload of Saturn could be increased between 50 and 100% through the use of a nuclear third stage, thereby reducing the number of Saturns required for orbital freight delivery by one-third to one-half. In another approach for reducing the number of Saturns required, a nuclear rocket system would propel the spacecraft from the earth orbit to a lunar orbit and then return to the earth orbit. The optimum use of nuclear stages with the Saturn could reduce the number of Saturns required for the orbital rendezvous approach for lunar landings by a factor of at least two.

Direct-Flight Approach

Another approach considered by many to offer higher probability of achieving a manned lunar landing at the earliest possible time is the direct-flight approach, in which a vehicle would take off from the earth and carry the manned spacecraft directly to the moon. The vehicle for such an application could be an all-chemical vehicle or a vehicle combining chemical and nuclear stages. A rocket using all liquid-propellant-chemical-combustion stages would require a takeoff thrust of 10.5 million lb and probably six stages to return a 15,000-lb capsule from the moon. The first stage would be made up of a cluster of seven 1.5 million-lb-thrust F-1 engines now being developed for NASA. All other stages could use hydrogen-oxygen propellants. The use of solid-propellant rocket engines in the first stage would require the development of significantly more thrust than the 10.5 million lb of the liquid-rocket system.

The combination of nuclear stages and chemical stages can provide major reductions in the thrust and vehicle weight required to perform the manned lunar-landing mission. The use of a nuclear third stage using a 4000-megawatt reactor would result in a vehicle having a takeoff thrust of 4.5 million lb rather than the 10.5 million lb of

the all-chemical rocket. The first-stage propulsion system would be made up of a cluster of three F-1 engines. The remaining chemical stages of the five-stage vehicle would use hydrogen-oxygen propellants. Still lighter vehicles could result from the use of stages having higher reactor powers. The reactor powers required for all of these lunar missions are in the same range as would be provided if we develop systems intended for planetary missions.

To summarize this space-mission discussion, the use of nuclear stages is required to permit the execution of manned planetary missions. Vehicles developed for the lunar missions could provide the freighter service required to deliver the planetary spacecraft into the earth orbit. The use of nuclear stages can reduce the weight of the lunar-landing vehicles by a half to two-thirds. If orbital rendezvous is to be used for the lunar mission, the application of nuclear stages could reduce the number of freighter vehicles required to deliver the necessary material into the earth orbit.

We must recognize, however, that success in the nuclear rocket program is not yet assured. We are developing a new and advanced technology. Our work to date has been very encouraging. In describing this work, I am in the position of trying to discuss, in an unclassified manner, a subject that depends heavily on classified information. For that reason, I will not be able to go into the details of technology or of the results we have obtained to date.

We have tested three research reactor devices with gaseous hydrogen as a propellant and water as the pressure shell and nozzle coolant. These tests provided us with necessary information on our design techniques and with an improved understanding of materials operating at conditions similar to those that will be encountered in nuclear rocket systems. This Kiwi-A series of tests was remarkedly successful, particularly for a point so early in the development of a new system.

The Kiwi-B series of reactor tests to be initiated later this year will include tests with liquid hydrogen as a propellant and as a coolant of all critical parts. Some of the areas requiring further evaluation in these Kiwi-B tests are the structural characteristics of the materials that will be utilized in flight reactor systems and the control characteristics and dynamics of operating reactors with liquid hydrogen as the propellant. The Kiwi-B series should lead to the development of reactors that will be used in the flight test of the first nuclear rocket system.

Both NASA and the AEC have agreed that it is essential that flight

Increased technical responsibilities in the field of range measurements have required the creation of new positions at the Lincoln Laboratory. We invite inquiries from senior members of the scientific community interested in participating with us in solving problems of the greatest urgency in the defense of the Nation.

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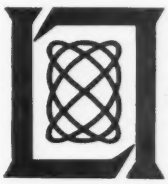

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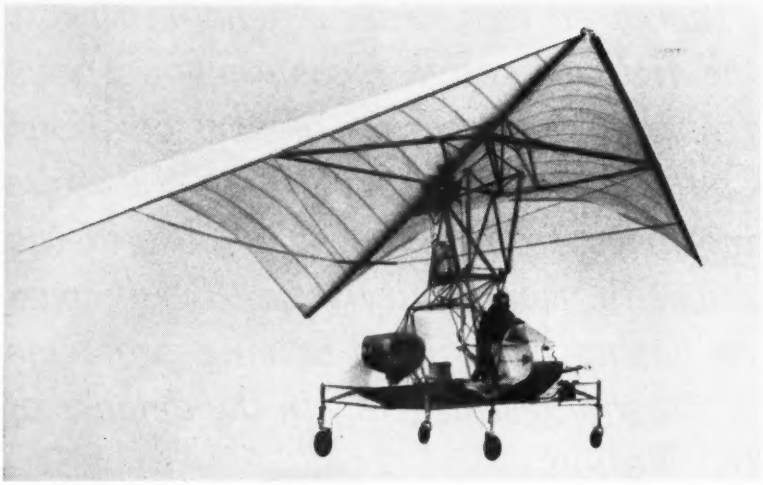

Flex Wing Up for Testing

The flex wing conceived by F. M. Rogallo of NASA-Langley for such jobs as recovering large rocket boosters, e.g., the Saturn first stage, gets tested in experimental form by Ryan's Aerospace Div. with this rig. Ryan is studying the engineering of the flex wing for NASA-Marshall and the Army's Transportation Research Command. The wing appears useful powered or unpowered, for manned and unmanned vehicles, at speeds up to the supersonic and at altitudes up to 200,000 ft.

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tests be conducted on a nuclear rocket system so that, at an early time, its operation in the flight environment can be evaluated and demonstrated. In addition, such flight tests will enhance our technological stature. We have had four contractors study the various approaches for flight testing. All these contractors recommend that the first flight tests should be conducted with a nuclear stage boosted by stages of the Saturn vehicle on a ballistic trajectory from Cape Canaveral. Such a flight-test approach could lead to the development of a Saturn vehicle with a nuclear third stage. Such a vehicle could provide 50 to 100% more orbital payload than can the all-chemical Saturn vehicle and two to three times the escape payload of the all-chemical Saturn.

Although we may not be able to overtake the Russians in the race for the moon, I must repeat that I believe we are ahead in the race for manned exploration of the planets. The work we have done to date on the nuclear rocket gives us the lead in that area. The planetary mission will not be performed unless nuclear rocket development is successful. Our long-term lead in space therefore requires that we treat the nuclear program with a strong sense of urgency, and that we support it accordingly. I am confident that we can develop the systems that we will need for such planetary missions. We must insure that we retain our lead in this area.

Use of Brute Force

I have thus far been discussing a program in which our manned space program would aim at Mars and Venus as our primary objective, with the moon mission as a secondary or preliminary objective. In this case, the nuclear rocket propulsion system will have to be our major propulsion development effort. However, if the manned lunar landing is, in the immediate future, to be given top national priority, and is to be pursued with all possible vigor in order to beat the Soviet Union on that particular mission, systems using the most developed state of art will have to be relied upon as the primary vehicle approach in achieving the mission. With such a national urgency placed upon our being first to the moon, we would be forced to use the surest technical approaches even if they are brute force, unsophisticated systems lacking in growth potential. Because of the comparatively large amount of experience with them, chemical-combustion rockets would certainly be chosen for this primary vehicle approach.

However, with such high national priority, backup or alternate approaches will have to be included in the program planning to fill the gap if insoluble difficulties are encountered in the primary vehicle approach. The cost of such backup development would be trivial when compared with the cost of performing the first manned lunar landing, which has been variously estimated at $15 to $40 billion. The development of the nuclear rocket as an alternate for the lunar landing is entirely consistent with its primary role in space—insuring that we will be the leaders in the race to the near planets. The power levels required for lunar and planetary missions are essentially the same. If our nuclear technology is developed sufficiently rapidly, and slippages due to technical difficulties arise in the large chemical systems, it may eventually be determined that nuclear stages should be substituted for chemical systems in lunar mission vehicles.

We must recognize that we cannot with assurance say that we will beat the Russians to the moon with any system because we do not know their time scale. In addition, because we have less experience with them, nuclear systems for lunar missions may lag the chemical systems. The nuclear-system development would provide an alternate approach for the lunar mission without jeopardizing our ability to lead in a manned race to the planets. As I have indicated earlier, the similarities between nuclear reactor engines for planetary and lunar missions are sufficiently great that the development of the nuclear rocket as a lunar-landing backup would still insure its availability for the planetary missions.

As I have said before, all nations face the same natural laws in performing these difficult space missions. The only differences that arise in the accomplishment of such missions are related to the national determination to do the mission. In this competition for survival, we must show our determination to win. The program will be costly; it will require the hard and sincere labor of our best people. But, since this is a survival competition, we have no alternative. We may lose in the premilinaries, but we must win in the long-term main events. ♦♦

COSPAR Again

(CONTINUED FROM PAGE 34)

munications experiments.

The USSR report cited launchings in 1960 of 167 scientific and 160 meteorological rockets from the USSR itself, from Franz Josef land, and from ships in the Pacific and in the Black Sea. Spaceship accomplishments, especially with reference to biological and scientific measurements, were discussed. (On another day, about 20 min of motion pictures were shown presenting some details of the training, the physical and mental preparation, and the flight and subsequent life of Belka and Strelka, the two space dogs.)

In its 1961 plans, the USSR report cited extended meteorological studies by sounding rockets that would reach altitudes of 415 mi., a significant advance over the 250- and 85-mi. altitudes claimed for 1960 flights. They also announced upper-atmosphere measurements by satellites and unspecified spaceship flights. Special mention was made of rocket observations early this year of the solar eclipse. Oriented observer stations were fired to 100 km (83 mi.) and were attitude-controlled during flight while they observed and measured the corona, recorded brightness data by several means, explored X-ray and ultraviolet radiations in the corona, and made quantitative measurements at less than 1300 Å. Finally, scattered and reflected ultraviolet radiation was measured in the lunar shade between 2000 and 3000 Å with several instruments covering 2-deg fields. Preliminary data reduction indicates a difference in the strength for different directions.

Venus Probe Kaput

The Venus probe: A weight of 643.5 kg was cited for this "automatic interplanetary station" which was "launched by a new method from an artificial earth satellite." Extremely high precision in control was claimed, limited only by the error introduced into the calculations by the unknowns of space. All internal subsystems were reported as operating normally, and no explanation was given for the failure of communications, except mention that the power source was apparently responsible.

Predictably, France was next to report its activities, followed by Canada, Japan, and Italy. West Germany, so far, has been a vicarious participant, operating on the data gathered by others and their own ground stations. The West German speaker jokingly stated that they had neither rockets

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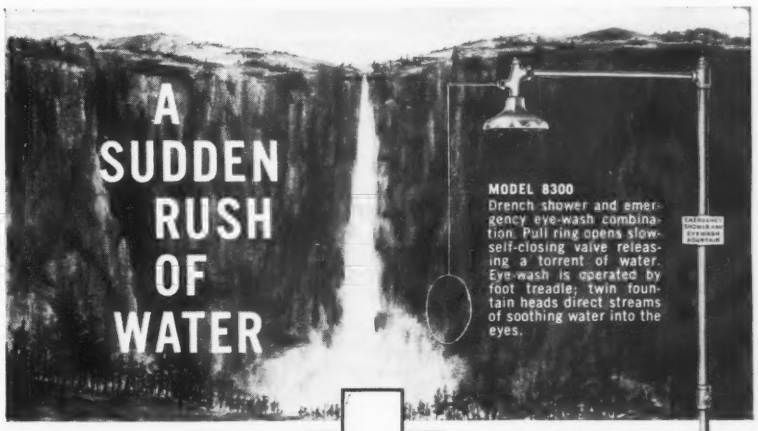
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nor deserts. The rest of the countries reporting were also passive participants, most of them cooperating with the U.S.

It was pleasing and surprising to see the interest and the expressed desire by so many countries to take part in the space age. Among the minority reports, it is noteworthy that South Africa specifically mentioned a great interest in communication satellites.

Reports from ICSU

COSPAR is a creation of the International Council of Scientific Unions, so the first day logically closed with reports of those four unions particularly interested in and concerned with space matters. The first was the International Astronomical Union, which welcomes cooperation with COSPAR, since they regard space research as an extension of astronomy. Their present prime interests are (1) determination of changes in the rotation of the earth due to magnetic storms of the sun, (2) allocation of adequate frequencies for space-science studies (in cooperation with URSI and COSPAR), (3) ultraviolet and X-ray studies of the sun, the stars, and the galaxies, and (4) celestial mechanics.

The International Union of Theoretical and Applied Mechanics (IUTAM) was reported on in fast French, from which I gathered that their main immediate concern is the sponsorship of, or participation in, symposiums on space and atmospheric matters.

The International Scientific Radio Union (URSI) has an active space radio research committee which (1) monitors the state of the art and advises URSI on its role, (2) advises COSPAR on space radio research matters, and (3) cooperates in requesting or controlling space radio research frequencies. URSI has two definite symposiums in mind: The first is being planned jointly by J. R. Pierce of Bell Labs and a Russian professor for somewhere in Europe in late 1961 or early 1962. The second, planned for 1962, will discuss maximizing information transfer from space vehicles.

URSI is particularly interested in high-precision synchronization of world time standards by the use of "low frequency" or "very low frequency" radio signals, using some sort of undescribed continuous monitoring to determine flight-path anomalies.

The last of the reports was from the International Union of Geodesy and Geophysics (IUGG), which has three active committees working on and recommending space programs. Their planned meetings are October 1961 in Kyoto, Japan; May 1962 in Cortina, Italy; June 1963 in Washington, D.C.; and one in 1963 in Los Angeles, immediately prior to the 13th IUGG annual meetings.

The remaining four days were devoted to technical papers. A volume of proceedings of the entire symposium will be printed in Holland and distributed to those requesting and paying for it. The volume should appear three to six months after the meeting. One curious circumstance of these presentations is probably worth remarking: All of the papers from the many countries represented were presented in English except those from France, given in French.

The other high point of the meeting was the reception given by the mayor of Florence in the Palazzo Vechio, the beautiful medieval town hall which has served his city for 500 years. After members of the COSPAR congress were seated in the large hall, the public was admitted and jammed all the remaining seats and the aisles. Punctuated throughout by flashbulbs and floodlights, and cameras being snapped, set, or reloaded, the mayor's speech fervently welcomed the guests of honor, Russian Professor A. Blagonravov, a beardless patriarch, and Professor A. G. Masevich, a small, neat, youngish pleasant-looking woman. The mayor's dramatic and emotional oratory praised the Russian space flight, thanked COSPAR for having made Florence a focus of the world during this dramatic time, and lauded COSPAR in sonorous references to Galileo and da Vinci. Prof. van de Hulst, president of COSPAR and the Congress, briefly responded to the mayor with thanks for COSPAR, apologizing that he had to substitute for the language of Galileo and da Vinci the language of Newton. Polite applause followed. Dr. Porter, a vice-president of COSPAR, then rose from the same head table to express, in unapologized-for English, a brief American appreciation of the flight of the Vostok.

Prof. Blagonravov, the other vice-president of COSPAR, then rose to tumultuous applause, which he completely topped by reading his speech in Italian. Every pause was punctuated with further tumultuous applause, and this was raised to some power when he introduced Prof. Masevich.

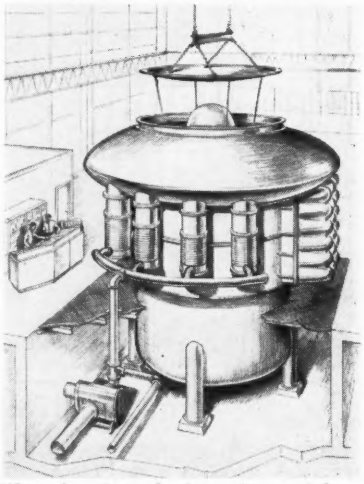
"Gina Lollobrigida"

What a surprise her speech was, since she began by apologizing for not being able to speak Italian and chose to deliver her talk in English. Her voice did not carry well and the speaker system was poor so I got little of what she said except her promise to be able to speak Italian when next she returns to Florence. Her talk, too, was paced by wild applause and cheers, and afterwards she was swarmed upon by autograph seekers as if she were Gina Lollobrigida.

The two stairways which lead into the main court on the ground floor of the Palace were completely jammed by people, who would not move until the two conquering heros had been treated to still more thunderous applause and cheers as they left the building. I was tremendously impressed and even moved by all of this.

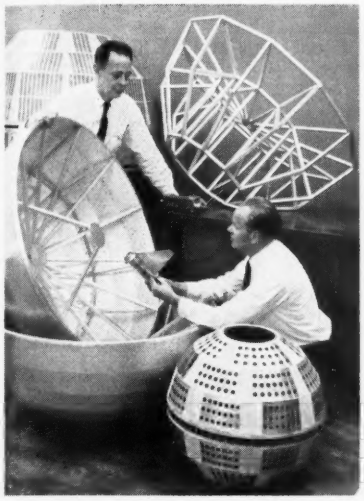
The next day and, indeed, several times later in the week, I talked to various people about it, and was brought down when I learned that I was apparently naïve; that in the eyes of not only Americans but also Italians the whole thing was a well-planned production sponsored by the extensive Communist population of Florence. It even appears to some that Prof. Masevich is playing a regular circuit, giving this same speech to the same hysterical response all over Italy. I would like still to believe that my first reaction of wonder and pleasure at the obvious interest of the public in this space age and the Russian space flight was true for at least some sizable proportion of the people in attendance that night. ♦♦

Grumman Building Space Simulator for OAO Tests



The drawing depicts the stainless-steel space simulation system being built for Grumman by the Chicago Bridge and Iron Co. Grumman will use the simulator at first to test a full-scale prototype of the Orbiting Astronomical Observatory which it is developing for NASA. The simulator will produce 10^{-7} mm Hg and operate in the temperature range of −320 to 350 F. Its inner chamber measures 19 ft in diam by 28 ft high.

Bell Labs Plan for Long-Lived Satellites



Bell Labs engineers John W. West, left, and Leif Rongved show developmental models of communication-satellite structures they are working with. Rongved holds a frame for attaching electronic equipment inside a satellite. Bell's President James B. Fisk recently commented that the Labs would develop artificial-sapphire shielding to protect the solar cells on their communication-satellite designs from radiation and micrometeorite erosion in space. Such shielding, he said, should give communication satellites a commercially useful lifetime perhaps as long as 10 years.

Proposed R&D Projects Publicized for Small Firms

During May the U.S. Dept. of Commerce began issuing daily proposed unclassified NASA research and development contracts leading to prime contract awards of $100,000 or more. The daily "Synopsis" includes a summary of requests for proposals, plus the names and addresses of firms which have been invited to submit proposals by NASA. The NASA Office of Public Information and all NASA field stations will, in addition, make available the names of firms attending pre-proposal briefings and, after the closing dates, those who submit proposals.

To subscribe to this service, contact the U.S. Dept. of Commerce, Administrative Service Office, Rm. 1300, New Post Office Building, 433 West Van Buren St., Chicago, Ill., or any of the 33 field stations of the Dept. of Commerce. Subscription rates for the daily synopsis are $10 per year by regular mail and $28 per year by air mail.

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ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner, *Thiokol Chemical Corp., Elkton Div., Elkton, Md.*

HYDRAZINE-TETRAFLUOROHYDRAZINE

The accompanying calculations were made on the IBM-7090 digital computer using the enthalpy balance method as presented by the author to the Ad Hoc Panel on Performance Calculations at Silver Spring, Maryland, on April 27, 1959.

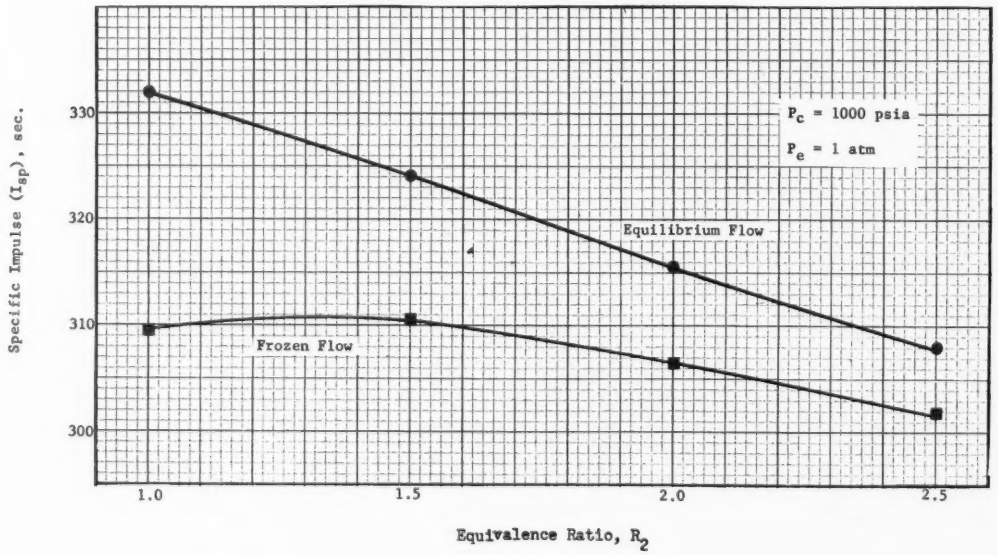
The constituents considered as possible combustion products were H, H_2, F, F_2, N, N_2, and HF. The thermodynamics data for these species were taken from the author's compilation (General Electric Report R59FPD796/Vol. 3).

The propellant heats of formation used were +12.05 kcal/mole for N_2H_4 and −2.0 (gas) for N_2F_4. Since the computational program is referred to 0 K, the inlet enthalpies for the propellants were +18.170 kcal/mole (N_2H_4 liquid at 25 C) and −0.878 kcal/mole (N_2F_4 liquid at −100 C).

N_2H_4–N_2F_4 Propellant Performance

R_2 (O/F)	1.00 (3.25)		1.50 (2.16)		2.00 (1.62)		2.50(1.30)	
Composition (mole %)	Chamber	Exit	Chamber	Exit	Chamber	Exit	Chamber	Exit
N_2	31.342	33.324	32.032	33.331	32.511	33.333	32.841	33.333
HF	55.469	66.604	50.261	53.330	43.144	44.444	37.477	38.095
H_2	1.390	0.018	9.946	13.326	19.423	22.222	26.729	28.571
H	4.484	0.010	6.743	0.013	4.712	.001	2.897	-
F	7.264	.045	1.002	-	0.206	-	0.055	-
F_2	0.001	-	-	-	-	-	-	-
N	0.050	-	0.015	-	0.004	-	0.001	-
Equilibrium Flow Parameters								
Pressure, Atm.	68.05	1.00	68.05	1.00	68.05	1.00	68.05	1.00
Temperature, °K	4431	2236	4060	1796	3687	1523	3396	1332
Enthalpy, cal/g	127.1	-1138.8	173.4	-1033.5	210.9	-934.5	241.9	-848.7
Entropy, cal/g-°K	2.6081	2.6081	2.7913	2.7913	2.9197	2.9197	3.0160	3.0160
Molecular Weight	21.340	22.672	19.492	20.277	18.219	18.679	17.278	17.537
Specific Impulse, sec.	-	331.9	-	324.1	-	315.7	-	308.0
Frozen Flow Parameters	(Pc=68.05; Pe=1.00 Atm.)							
Exit Temperature, °K	-	1586	-	1467	-	1333	-	1224
Throat Temperature, °K	3847	-	3534	-	3212	-	2960	-
Throat Pressure, atm.	37.09	-	37.15	-	37.17	-	37.19	-
Characteristic Velocity, ft/sec.	6457	-	6478	-	6390	-	6294	-
Thrust Coefficient	-	1.541	-	1.543	-	1.543	-	1.543
Specific Heat Ratio	-	1.322	-	1.318	-	1.318	-	1.319
Specific Impulse, sec.	-	309.3	-	310.6	-	306.4	-	301.9

N_2H_4–N_2F_4 Performance



CUT ALONG THIS LINE

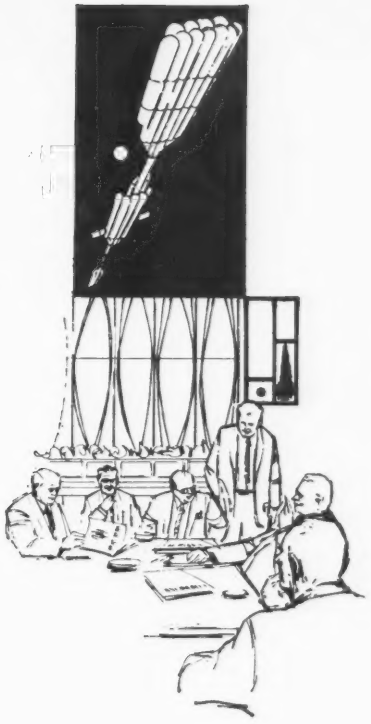
New York Coliseum

October 9-15, 1961

AMERICAN ROCKET SOCIETY

SPACE FLIGHT REPORT

TO THE NATION



Through the medium of the ARS SPACE FLIGHT REPORT TO THE NATION, the American Rocket Society, during the week of October 9-15, 1961, in New York Coliseum, will present a thorough and comprehensive review of the U. S. space program.

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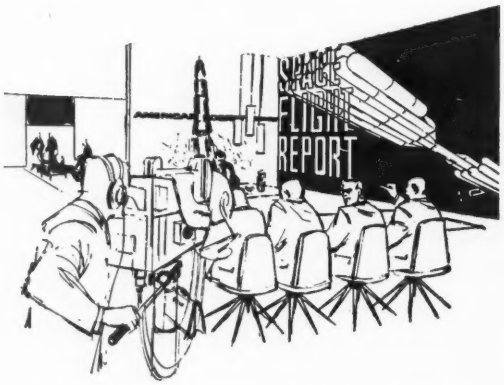
- The history, purposes, and plans of ARS graphically displayed in a booth designed by Raymond Loewy.



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Electrical Propulsion

(CONTINUED FROM PAGE 27)

pulsion Systems," by J. W. Stearns of JPL, presented at the recent ARS Space-Nuclear Conference, ARS Preprint No. 1751-61). With this system it would be possible to propel useful payloads to practically all the planets (Mercury, Venus, Mars, Jupiter, Saturn, and Pluto) and the sun. Also, this system would be capable of establishing satellites with reasonable payloads about most of the planets. For example, it could transport around 20,000 lb from a low earth orbit to a Venus orbit in 8 months. A 1-megawatt system could transport heavier payloads, but would probably be more useful in propelling good-sized payloads to the planets in less time.

The procedure commonly considered for using electrical propulsion is to launch from a low earth orbit. Advanced missions would involve rendezvous of payloads that are boosted from the earth into a low, 300-n.mi. orbit. The final planetary spacecraft, manned or unmanned, would be assembled in low orbit and then an electrical system would propel the spacecraft to the vicinity of the destination planet. In either instance, to control the starting sequence of the complex nuclear-electric stage better, establishing the stage in a low earth orbit before startup appears desirable. It is interesting to note that the Russians used this parking-orbit technique on their recent Venus shot, although an electrical stage was not reported.

Hypothetical mission analysis for advanced electrical-propulsion systems is a very popular subject today. But when electric propulsion began to be seriously considered for space flight, technical problems were prominent in many areas, and it was not possible to define a specific system in sufficient detail to justify an expensive development program.[1] Fortunately, the potential of the field was recognized, and research was initiated on the technical problems which had to be overcome before an operational system could be developed. The basic components of the system were classified as Power Source, Thermal to Electric Conversion System, Radiator, Propellant, and Thrust Chamber.

Since the power source, conversion system, and radiator problems were of interest in the auxiliary power generation field and not specifically confined to the development of a flyable electric engine, research and development of these components proceeded independently. A further division of effort took place in the development of these components based on the type of power source—nuclear or solar. The two systems that are most advanced in development at NASA today are Sunflower, a 3-kw solar electrical power conversion system, and Snap-8, a nuclear-electric system being designed to produce electrical energy at the 30- and 60-kw levels. (The Air Force is also developing the Snap-2 nuclear-electric system, which is designed to produce 3 kw.)

Power Requirements

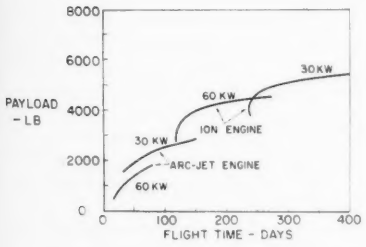
However, these low power levels are a long way from the 300- to 1000-kw range that mission studies indicate are desirable for electrical propulsion. Why use a 30-kw or even a 60-kw system when mission studies illustrate the need for higher power systems in the 300- to 1000-kw range? Why not just develop a light, high-powered system as a first step?

Some idea of the magnitude of these power requirements can be drawn from a comparison with an average U.S. residential city of 10,000 persons. Such a city requires approximately 970 kw of electrical capacity. Furthermore, the electrical propulsion system for space travel must be reliable for a long time (months to years) and be fairly lightweight (10 lb/kw). The answer to the question of why we are not building an electrical system that fits the needs shown by mission studies is simply that we do not now have reliable, lightweight powerplants to meet these criteria. Studies are being made to define better the technical problems that must be overcome before a 300- to 1000-kw system can be built. The AF is sponsoring the study of a 300-kw system (Spur) with AiResearch Mfg. Divs. of Garrett Corp. and Aerojet-General Nucleonics Div. All reactor development is under direction of the AEC, which is investigating the feasibility of the higher powered reactors. Also, NASA is investigating the problems in the power-conversion field for a 1-megawatt system. All of these programs are proceeding along a normal research and development path with very limited funding. Since there is no official mission planned for a high-powered electrical system, there is no assigned priority to the component projects other than to continue research and development.

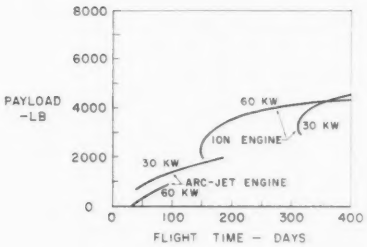
While the power supply, conversion, and radiator component development is proceeding rather normally, what is the status of propulsive devices—the electric engines which propel the spacecraft?

When work began on electric engines, several different schemes were considered. Many of the possibilities are outlined on page 26. The three systems which have progressed to development phase are commonly known as ion, arc-jet, and magnetohydrodynamic drives. However, a more formal nomenclature that is gaining popularity is electrostatic, electrothermal, and electromagnetic drives. With these three types of space propulsion engines, it is possible to cover a very wide range of specific impulse. The arc jet is expected to operate from 800 to 1500 sec, the ion engine from 4000 to 10,000 sec and possibly higher. MHD devices, which are not as near flight status, are expected to overlap the specific-impulse ranges of

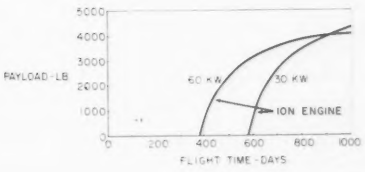
Electrical-Propulsion Spacecraft Missions with Snap-8 Power Supply



24-Hr Equatorial Satellite



Lunar Satellite



Mars Orbit at 500 Miles

the ion and arc-jet engines. Thus, electric engines provide propulsion in the specific-impulse range above the capabilities of chemical and nuclear rockets.

Why is it necessary to have engines for the complete specific-impulse spectrum? Why not just concentrate on the big payoff and develop very high specific impulse engines? Can't one type satisfy the complete range?

In the quest to develop engines with high specific impulse, it soon became apparent that no single device could be readily built to operate in the wide range from 800 to 10,000 sec or higher. Since many technical problems confronted electric engine developers, the performance characteristics of the engines were hard to specify. Additional research was required in many areas to demonstrate the feasibility of a concept, and this research could be performed for a rather moderate cost. It was not clear whether the high-impulse ion engine could even operate because of beam-neutralization problems. Also, MHD devices were not well understood, and more research was necessary to examine the complex interaction between the plasma and electric and magnetic fields. While the ion and MHD systems had the greatest potential for deep-space missions using high-powered reactors, the arc-jet problems appeared much simpler and this system showed some potential—especially if the other electric devices were not feasible.

High Isp Engine Development

With this reasoning, a three-way program to develop high specific-impulse electric engines was initiated. Valuable technical contributions have been obtained for a modest investment in this rather broad engine-development program. The limitations of each type of electric engine can now be better defined.

A specific impulse of 2000 sec appears to be a maximum for the arc jet, and this system operates more efficiently in the lower end of the electric engine's specific-impulse spectrum, around 1000 sec. At the higher values, excessive heat losses occur and the system cannot be adequately cooled. Gaseous hydrogen is usually proposed as propellant in most designs, and the process involves expansion of the plasma through a nozzle to create thrust. The term arc jet is used because the neutral propellant is heated to become a plasma by passing it through an electric-arc discharge.

At the other end of the spectrum, it is difficult to operate a surface-contact ion engine efficiently at a specific impulse less than 5000 sec due to beam formation and focusing problems. In this type of engine, neutral cesium is passed through, a hot porous-tungsten partition and cesium ions are literally boiled off. The cesium ions are focused into a beam, accelerated to high velocity, and then neutralized by injection of electrons. To lower the specific impulse of this design of ion engine, a decelerate system is used to slow the ions down before the beam is neutralized. Also, rather than use porous tungsten, cesium can be sprayed on a hot solid-tungsten surface; the Russians have been reported using this reverse-feed technique. NASA-Lewis has done considerable research on reverse feed for cesium-ion engines.

Other types of ion engines show great promise—at least for early applications.[2] A bombardment-type engine which uses mercury for propellant has been developed at NASA-Lewis. This system ionizes mercury through collisions with electrons. The mercury ions are then extracted from the plasma and accelerated through a grid before the ion beam is neutralized.

Beam Neutralization

The question of beam neutralization has been a topic of much interest and debate for years. Although there probably are still some who doubt that an ion beam can be neutralized in space, most workers in the field no longer consider this an impossible problem. There are widely varying neutralization schemes, ranging in complexity from a simple wire or filament to a sophisticated electron trap. The different neutralization systems are planned to be tested by NASA-Marshall SFC in short ballistic flights using battery-powered ion engines. The test packages will be launched by Scout vehicles. Plans call for the first engines to be flight tested in 1962. As a result of theoretical analyses and laboratory experiments thus far, there is every reason to believe that an ion beam can be neutralized in space. It would not be surprising to hear of the Russians making equivalent tests before too long.

To overlap the specific-impulse ranges of ion and arc-jet systems, MHD devices are planned. Research

The Newly Proposed NASA Funding for FY 1962

Area of Work	Original (Jan. '61)	Revised (March '61)	Proposed (May '61)
Support of NASA plant	$ 74,310,000	$ 77,110,000	$ 89,110,000
Research grants and contracts	7,600,000	7,600,000	7,600,000
Life sciences	8,620,000	8,620,000	20,620,000
Sounding rockets	7,000,000	7,000,000	9,000,000
Scientific satellites	64,700,000	64,700,000	72,700,000
Lunar and planetary exploration	103,899,000	103,899,000	159,899,000
Meteorological satellites	28,200,000	28,200,000	50,200,000
Communication satellites	34,600,000	44,600,000	94,600,000
Mercury	74,245,000	74,245,000	74,245,000
Apollo	29,500,000	29,500,000	160,000,000
Launch-vehicle technology	15,000,000	15,000,000	27,000,000
Launch-operations development	9,500,000	1,500,000	1,500,000
Spacecraft technology	10,360,000	10,360,000	10,360,000
Solid propulsion	3,100,000	3,100,000	3,100,000
Liquid propulsion	68,700,000	78,020,000	93,020,000
Electric propulsion	6,800,000	6,800,000	6,800,000
Nuclear-systems technology	24,000,000	28,000,000	36,000,000
Space-power technology	5,500,000	5,500,000	5,500,000
Scout	3,675,000	3,675,000	3,675,000
Delta	2,900,000	2,900,000	2,900,000
Centaur	30,800,000	56,400,000	56,400,000
Saturn	168,160,000	224,160,000	224,160,000
Tracking and data acquisition	38,650,000	38,650,000	38,650,000
Nova	—	—	48,500,000
Total approximations	$819,819,000	$919,539,000	$1,295,539,000

on MHD devices has not advanced sufficiently to define clearly engine-performance parameters, and consequently MHD devices are not as near flight status as ion and arc-jet systems.

While all this technological advancement is interesting, how does it affect our electric-engine development program? What missions can be accomplished with these ion and arc-jet engines, and what is the growth potential of each system? We know that a nuclear-electric system in the 300- to 1000-kw range is desirable, but can we perform any useful space missions with our present technology?

Applications

The first applications of electric engines can be divided into two categories—prime propulsion and vehicle stabilization. The solar-electric Sunflower system is being built to produce 3 kw of electric energy. The 3-kw level is much too low to be used as a prime propulsion source, but may have a wide range of application as an auxiliary power system, or as a satellite-stabilization and attitude-control system using low-thrust electric rockets. Plasmadyne Corp. is developing a thermal arc-jet engine which can be used with Sunflower. This engine is approaching the flight-test phase and NASA expects to have the flyable arc-jet engine in 1962. Integrating this engine into the Sunflower power supply for a particular spacecraft is not planned until the engine has been successfully flight tested. No major problems are anticipated for the engine, although it is necessary to test the propellant feed system, engine start and restart capability, thrust level, thrust vectoring, and many other things before the system is reliable enough for use in stabilizing an expensive spacecraft.

The 30- and 60-kw Snap-8 nuclear-electric system will be the first power supply that NASA can use for prime propulsion of spacecraft. The reactor for this system is being developed by NAA's Atomics-International Div. under AEC contract. Aerojet-General is developing the Snap-8 turbogenerator conversion system under NASA contract. The engine development program for prime propulsion systems is very active. Avco's Research and Advanced Development Div. and GE's Flight Propulsion Laboratory are developing arc-jet engines for NASA that will operate at the 30-kw power level. Plasmadyne is also developing a 30-kw arc-jet engine under AF contract.

In ion propulsion, Hughes Aircraft is developing a surface-contact cesium-ion engine for NASA. NASA-Lewis has a bombardment-type mercury ion engine and other types of ion engines in their extensive research program. Electro-Optical Systems is developing an ion engine under AF contract. Moreover, research on some type of electric engine is under way in practically every major company in the space business.[3]

With this impressive amount of effort already underway, what can the Snap-8 ion or arc-jet engine combinations do and when might they be expected to become useful?

In considering applications of Snap-8 electric-engine systems for space missions, the engine characteristics are very important. The graph on page 27 shows typical engine efficiencies for ion and arc-jet systems which are nearing flight status. Since the effect of engine performance is critical for mission analysis, some discussion is warranted of these engine efficiency curves.

Gaseous hydrogen is usually considered as the propellant in most arc-jet designs, even though helium has higher efficiency in the nominal operating range of specific impulse (800 to 1500 sec). The principal reasons for this selection are storage and handling problems. Helium is the most difficult of all gases to liquefy, condensing at a temperature more than 16 C lower than hydrogen. However, the use of hydrogen on mission spacecraft may be impractical due to the necessity of storing it cryogenically for long periods. Non-cryogenic propellants such as ammonia may be more desirable for arc-jet missions. For an appraisal of applications, the arc-jet efficiency curve is based on the use of hydrogen as propellant, with frozen flow through a 100:1 area ratio nozzle from a chamber pressure of 1 atm with a 98% velocity coefficient and full regenerative cooling. These efficiency values may improve with technological advances, especially if some recombination is possible in the exhaust nozzle. However, the assumption of 100% regenerative cooling is quite optimistic, and the curve shown is probably fairly realistic for a system to be built today.

Two types of ion engines are currently being developed for possible use

Behind Titan II—Modern Production Power

The $15-million anhydrous-hydrazine plant built for the Air Force in a record time of nine months by Olin Mathieson Chemical Corp.

The world's largest plant for manufacturing the powerful storable liquid propellant, anhydrous hydrazine, recently went into volume production at an Air Force station in Saltville, Va. It was built in a record nine months and will be operated for the AF by Olin Mathieson Chemical Corp. under a three-year $25-million contract. The plant itself cost $15 million. Highly automatic, it requires only some 100 men for round-the-clock operation. Its entire output goes to the AF to support the Titan II program. The plant's capacity is classified. The fuel for Titan II is a mixture of UDMH and anhydrous hydrazine. A modified Titan II will be used as a booster for Dyna-soar and as a backup on certain NASA programs.

with the Snap-8 power supply. The bombardment ion-engine curve is shown for a constant loss of 1000 ev per creation of a mercury ion with 80% propellant utilization. This type of engine is being developed at NASA-Lewis, and the efficiency curve may be quite conservative. Lewis estimates that it may be able to achieve a combination of 500 ev/ion and 80% propellant utilization by the time the Snap-8 system is planned to be available for flight in 1965.

Cesium-Ion Engine

The curve for the cesium-type ion engine is based on an ion current of 20 ma/cm^2, 40% ionizer efficiency, a neutralizer power requirement that is 25% of the ionizer power, and a 95% propellant utilization. The curve is probably optimistic in terms of what this type of ion engine can produce today. Current values of 10 ma/cm^2 are quite common, but the value of 20 ma/cm^2 is considered reasonable. The cesium-ion engine is considered very useful for the higher power levels of 300 to 1000 kw where specific impulses of 8000 to 10,000 sec and long operating times will be desirable.

For convenience, only the expected performance of the bombardment ion engine will be considered here. On the basis of these efficiency curves, the cesium engine would be superior at long flight times or when a specific impulse over 7000 sec is desirable. It is much too early in the development cycle to determine which engine design will be superior and both designs are being further developed.

The present plan is to flight test complete Snap-8 ion and arc-jet systems in 1965 and, as mentioned, to begin engine flight testing in 1962 using battery power. Although we do not yet have any officially planned missions, there are several interesting possibilities, all of which could be flown long before 1970.

Using the preceding engine efficiency information, United Aircraft performed a mission comparison under NASA contract for the two possible power levels of Snap-8. The calculations were based on an 8500-lb spacecraft placed in a 300-mi. earth orbit by a Centaur launch vehicle. Three missions which served to illustrate Snap-8 and electric-engine performance were a 24-hr equatorial satellite, a lunar satellite, and a Mars satellite. The graphs on page 103 summarize the study. Payload was defined as the weight of the spacecraft at destination minus that required for propulsion and structure. Thus, the payload does *not* include the weight of the Snap-8 power supply. This is considered a "bonus" and could be used as an auxiliary power-generation system when the payload reaches the destination. The Snap-8 system was assumed to weigh 2000 lb for 30 kw (66 lb/kw) and 3000 lb for 60 kw (50 lb/kw). The length of the mission curves represent the specific-impulse range shown on the engine-efficiency curves. The lower limit of the curves is the point where maximum thrust is obtained. A more detailed report of the study has been given by T. N. Edelbaum of United Aircraft.[4]

Several conclusions reached in the UAC study serve to summarize a realistic appraisal of this first-generation nuclear-electric propulsion system:

1. For payloads below about 4500 lb, spacecraft with ion engines powered by the 60-kw Snap-8 can perform missions in a shorter time than those powered by the 30-kw Snap-8. For payloads larger than 4500 lb, the 30-kw system provides shorter flight times; however, this superiority is primarily of academic interest, since the corresponding flight times tend to be prohibitively long with either system.

2. For any given payload, spacecraft with arc-jet engines powered by the 30-kw Snap-8 can perform missions in a shorter time than those powered by the 60-kw Snap-8. The 30-kw system appears to be preferable for arc-jet engine applications unless power in excess of 30 kw is required for purposes other than propulsion.

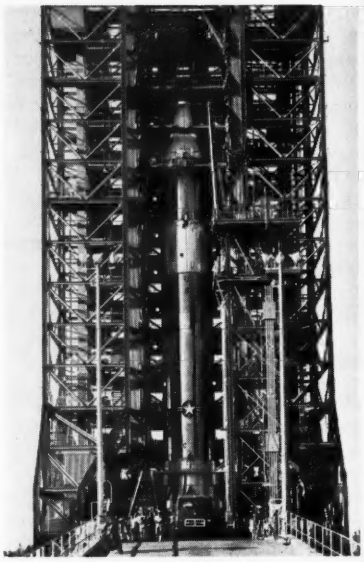
3. Arc-jet engines can perform the 24-hr and lunar-satellite missions in a shorter time than ion engines, but cannot carry as much payload. Arc-jet engines are incapable of performing the Mars-satellite mission.

While the performance figures for the Snap-8 system are far from those of future high-powered systems, it is encouraging to see that this system can perform very useful missions.

Electric propulsion is desirable in the 300-to 1000-kw range (with specific power varying from 10 to possibly 1 lb/kw) for the upper stage of the Saturn vehicle. But the Snap-8-ion engine Centaur system can be an important stepping stone toward this high-performance level.

As the graph on the Mars Mission shows, payloads of around 2000 lb can be transported to a 500-mi. Mars orbit in 425 days using a 60-kw system on a Centaur vehicle and a bombardment ion engine operating at an Isp of 6000 sec. The growth potential of electric propulsion is easily illustrated by considering advanced electric systems for the same Mars mission. There are a number of studies to show that an ion-

First Centaur Up



The first Atlas-Centaur goes up for a facility checkout at its Complex 36 at Cape Canaveral. The 105-ft-high vehicle, being developed by GD-Astronautics for NASA, will be flight-tested late this year.

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propelled spacecraft at the 1000-kw level could increase the payload capability of a Saturn C-2 by a factor of six and could make the trip to Mars in the same time.

The effect of improved systems can also be demonstrated by considering the lunar mission. A 60-kw, 4000-sec ion-engine system can propel 4000 lb to lunar orbit in 150 days. If a 300-kw, 10-lb/kw system were available, this same payload could be transported in 30 days.

Early Development Important

There are many benefits that can be achieved by developing a complete nuclear-electric system of the Snap-8 category rather than wait until our technology advances to the point where a 300 to 1000 kw, direct thermal to electric conversion system is available. The advancement of spacecraft design, payload shielding, low thrust guidance and navigation problems also represents a good reason why early systems development is important.

The use of a Snap-8 ion engine combination with a Centaur vehicle is not intended to represent an optimum use of electrical propulsion. This type of system is definitely power-limited and quite heavy (50–65 lb/kw). It will be very limited in its capability to perform deep-space missions. This does not detract from the potential of this field, but merely illustrates that Snap-8 is only a first-generation nuclear-electric system.

To conclude, let me iterate that we need to keep in mind the work of others on electrical propulsion and reassess our present work. It is my opinion we should concentrate on the high specific-impulse systems and not dilute our efforts by developing different systems to cover the complete spectrum of specific impulse. The following priority appears logical for developing electrical propulsion systems:

1. Accelerate development of a 300- to 1000-kw power supply with a specific weight of 1–10 lb/kw for use as an upper stage for Saturn.

2. Accelerate development of a complete spacecraft based on a 60-kw Snap-8 ion-engine propulsion system for the Centaur vehicle. This spacecraft would be a valuable step in performing useful missions and helping to further the development of technology for deep-space missions.

3. Continue to pursue an aggressive research program to develop new engine concepts for high-powered electrical propulsion systems. The MHD effort appears very promising and should be fully investigated.

4. Develop a flyable 30-kw Snap-8 arc-jet system only if a unique application exists.

A possible example of arc-jet use is the 24-hr active communications satellite. The arc jet can propel adequate payloads to the desired location and can then be used for corrective propulsion in maintaining the satellite in a precise location with respect to the earth. The 30-kw Snap-8 could be used as the power supply for a communications payload in stationary orbit. Since adequate payloads can be transported in less time than with an ion engine, the arc-jet system appears more desirable for this mission. Also, the Centaur and Snap-8 arc-jet combination could probably perform this mission at less cost than is possible with the larger Saturn vehicle.

Cryogenic storage of hydrogen does not appear attractive for this mission due to propellant-tank insulation requirements. An Avco-RAD artist's conception of a noncryogenic, ammonia-propelled spacecraft for this 24-hr satellite mission appears on page 27.[5] The rapidly growing field of satellite communications and TV transmission could make a separate arc-jet spacecraft development justifiable, especially if the 30-kw is available sooner than the 60-kw version of Snap-8. However, if this project is considered desirable, it should be separate from the 60-kw Snap-8 ion-engine effort, since two different types of spacecraft developments are involved.

At present, we have plans to flight test 30-kw ion and arc-jet engines with a Snap-8 power supply in 1965, although no missions are officially planned. Thus, we have a great opportunity to establish a superior position in this new field. By clearly defining our objectives and accelerating our efforts, we can avoid going through a phase of space exploration which might come to be known as the *"electric gap."* The challenge confronts us now. We should not miss our opportunity

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5. "Arc Jet Propelled 24-Hour Active Communications Satellite Preliminary Vehicle Design Study," Research and Advanced Development Div., Avco Corp., May 9, 1961. This Special Interim Report was prepared under NASA contract NAS5-1033. ♦♦

Manned Space Station Shape

Goodyear Aircraft will build a 24-ft-diam inflatable tube like this for NASA-Langley, which is testing such structures for manned satellites (see the article by E. Schnitzer in the Jan. 1961 *Astronautics*).

Wings for Mach 12

Aerojet-General's Spacecraft Div. has perpared these solid steel half-span model wings for aerodynamic testing at high Mach numbers in the Arnold Engineering Development Center's tunnels. The work is part of an Aerojet study program for the Air Force Systems Command's Aeronautical Systems Div. at Wright-Patterson AFB. Five basic wing designs will be tested for flutter analysis, and will give complete data on lift, drag, and stability.

OAO Operating System Under Development

Under development for NASA's Orbiting Astronomical Observatory by IBM Federal Systems Div. is an operating system that will contain all the control, memory, and data-processing elements to carry out complex experiments with the satellite's sensors on command from the ground—clock with timing generator and time-comparing logic, command decoder and distributor, command storage, delay-line logic for digital control of the attitude subsystem, data programmer, and data storage.

The operating system's ferrite-core memory will store 204,800 bits, which it will be possible to read out nondestructively in 7.5 sec. Nondestructive readout will permit multiple interrogations of the entire memory while an OAO is in range of receiving stations, and thus will improve reliability of transmitted data under poor signal-to-noise conditions. Moreover, triple modular and quadruple component redundancy will bulwark operational reliability, which is aimed at a minimum of one year of operation.

The memory for this OAO operating system has the largest capacity of its type known to be under development for space applications.

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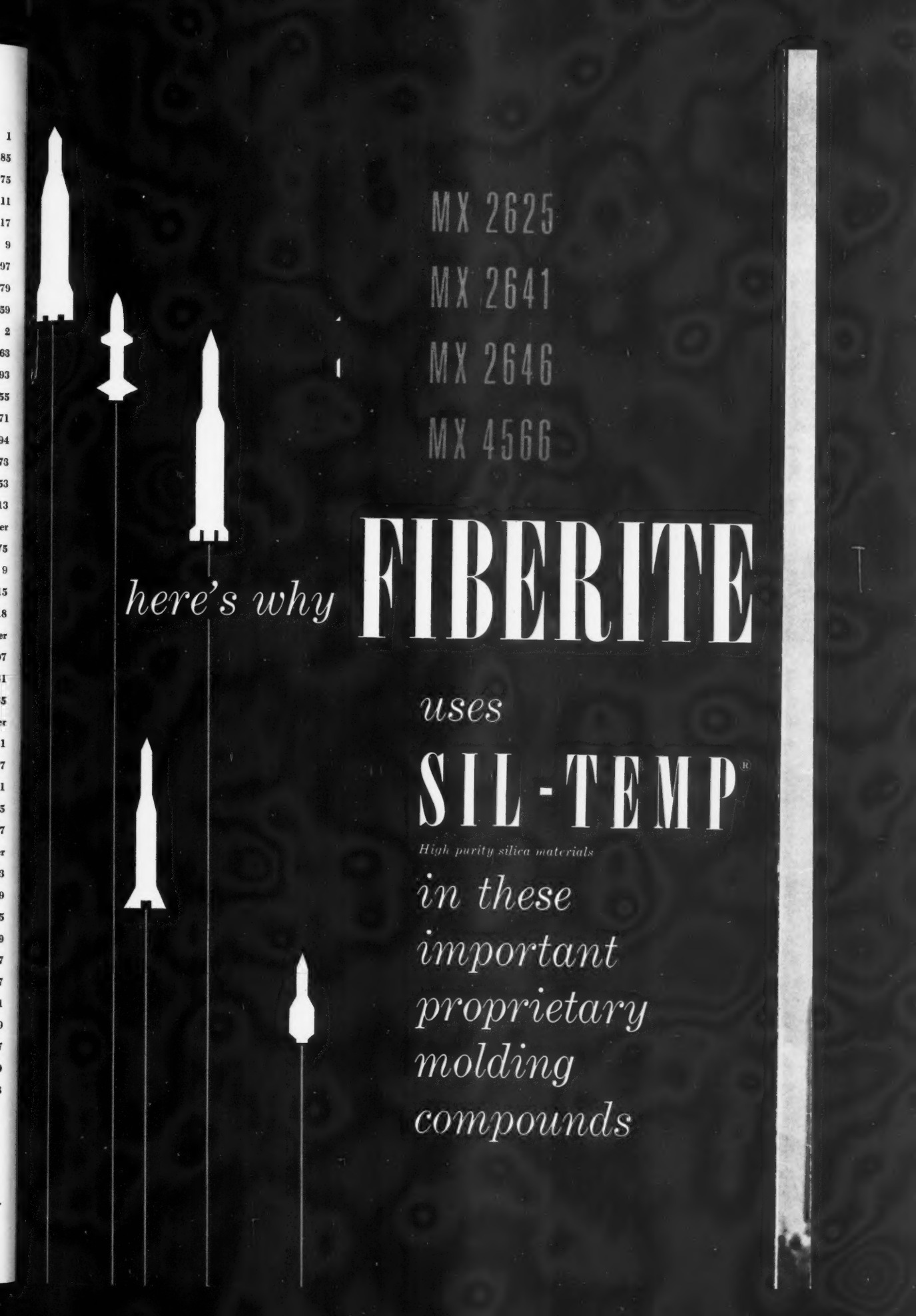
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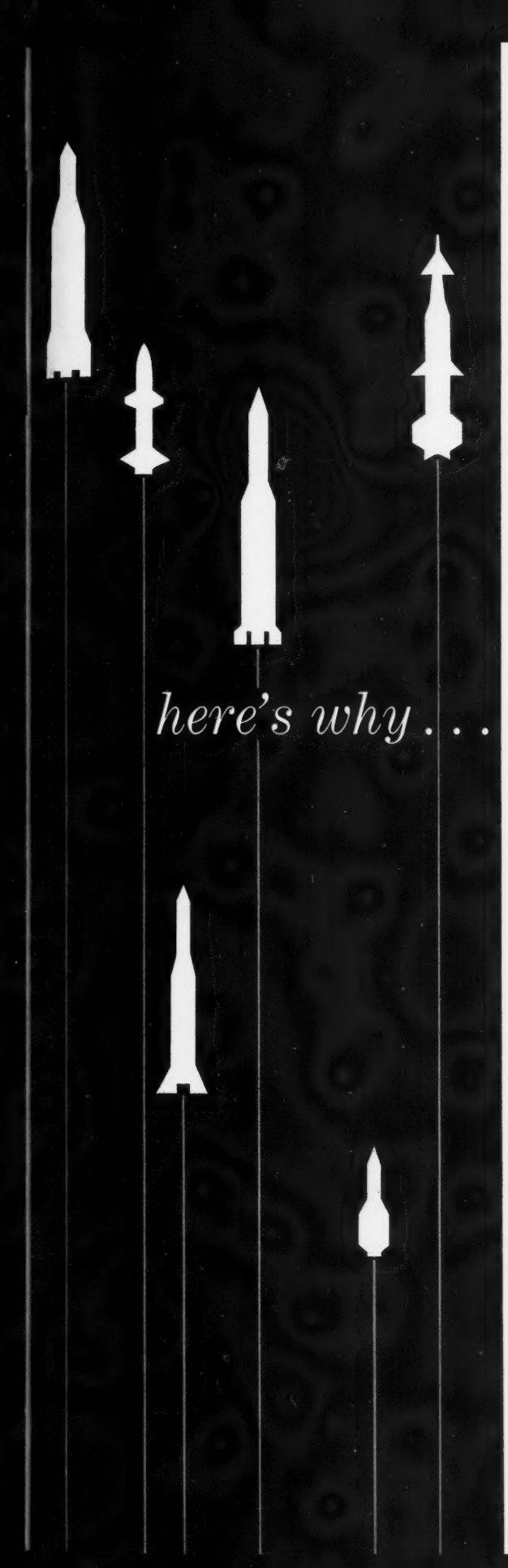

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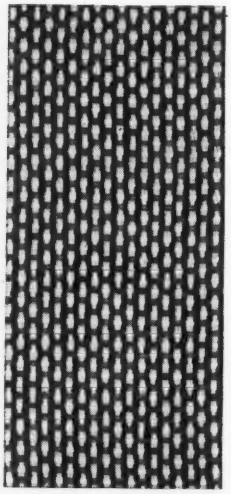

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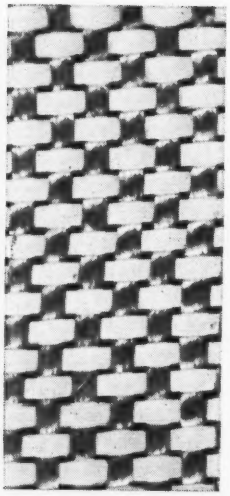
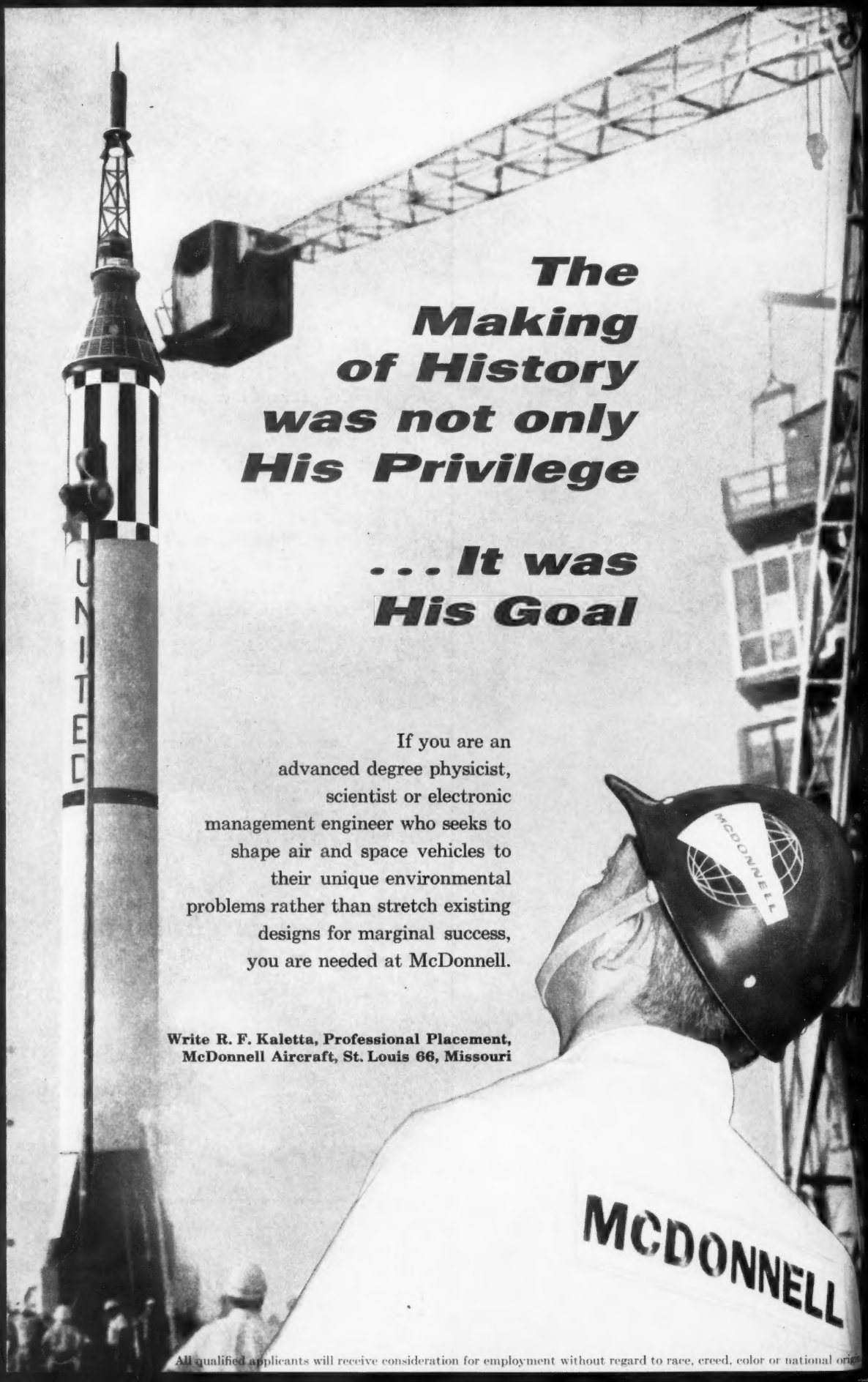


SIL-TEMP 175 WOVEN ROVINGS
MX 4566



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